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THE HEATING AND VENTILATING MAGAZINE

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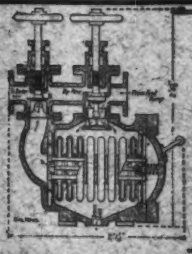

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THE HEATING AND VENTILATING MAGAZINE

1123 BROADWAY NEW YORK DECEMBER, 1911

Organic Matter in the Expired Breath

RECENT EXPERIMENTS SHOWING THAT RESPIRED AIR CONTAINS MANY SUBSTANCES, NOT YET DISCERNIBLE, SOME OF WHICH MAY HAVE AN IMPORTANT BEARING UPON HEALTH

BY MILTON J. ROSENAU AND HAROLD L. AMOSS

The efforts being made by the medical fraternity to solve the question of the real cause of the ill-effects of vitiated air are well illustrated in an exhaustive series of experiments conducted by Milton J. Rosenau and Harold L. Amoss, of the Department of Preventive Medicine and Hygiene, Harvard University, which are reported in detail in the *Journal of Medical Research* for September, 1911. A description of the tests and the principal results obtained are given herewith:

The presence of organic matter in the expired breath has long been suspected but never demonstrated. These substances have eluded chemical tests; and animal experimentation has heretofore furnished contradictory and inconclusive evidence. The writers here present results which they believe demonstrate that the expired breath contains organic matter and that this organic matter is specific in nature.

In the early experiments of Claude Bernard (1857) animals were confined in atmospheric air and in mixtures both richer and poorer in oxygen than atmospheric air. He explained the poisonous effects of carbonic acid when respired to be due to the fact that it deprived the animal of oxygen. Similar results were reported by Valentin and by Paul Bert. Richardson, in 1860-61, found that a temperature much higher or lower than 20° C. had the effect of shortening very considerably the lives of animals confined in an unventilated jar. Pettenkoffer shortly thereafter (1860-63) believed that the symptoms observed in crowded ill-ventilated places were not produced by the excess of carbonic acid nor by a decrease in the proportion of oxygen in the air. He further did not believe that the impure air of dwellings was directly capable of originating specific diseases or that it was really a poison in the ordinary sense of the term, but that it diminished the resistance on the part of those continually breathing such air.

The animals exposed to Brown-Séquard to the expired breath of other animals died and he believed they died as a result of poisonous matters in the expired breath. Whether these poisons were of organic nature or not could only be surmised; in fact, their very presence was vigorously denied by Billings, Mitchell, Bergey, and others who repeated Brown-Séquard's

experiments with contradictory results.

The ill-effects from breathing air contaminated with the expired breath is now generally assumed to be due to the increased temperature and moisture rather than to the poisons which have so long been suspected and sometimes taken for granted. Thus Benedict has kept persons in his calorimeter breathing and re-breathing the same air with a CO_2 content as high as 2% for 24 hours without discomfort, the only precaution being to keep the temperature down and to remove the moisture. It is to be noted that in these experiments some of the air was passed over lime and sulphuric acid every two hours, and the greater part of the moisture was removed by condensation, which may also remove other substances than the carbonic acid and moisture.

EXPIRED BREATH STERILE WITH QUIET RESPIRATION

One of the notable achievements of bacteriology was to show that the expired breath during normal quiet respiration is practically sterile. The moist mucous membranes of the upper respiratory passages act as a bacterial trap. Before this demonstration it was assumed, and commonly believed, that many of the communicable diseases were transmitted from person to person through specific poisons contained in the expired breath. The fact that the expired breath usually contains no bacteria robbed it of much of the horror with which it had long been regarded. When science demonstrated that the expired breath was not particularly dangerous, so far as the specific viruses of the communicable diseases are concerned, it was entirely acquitted and given a free bill of health in the minds of many sanitarians. Flügge's demonstration of droplet infection and its possibilities partly restored the expired breath to a position of possible danger.

Our changing views towards the dangers in the air are well illustrated by the attitude of the surgeon. At first Lister and his followers in antiseptic surgery attempted to sterilize the air coming in contact with the wound. The work of Pasteur, Tyndall and others had fostered the belief that the air was full of dangerous bacteria. The surgeon now largely disregards the air of a well-appointed surgical clinic. He, however, ties pieces of sterile gauze about his mouth and nose and over his hair to prevent contamination by these sources.

Since it has been shown that the air under ordinary circumstances is not usually the vehicle by which the communicable disease and the infections are conveyed, the pendulum has swung to the other extreme, especially as no harmful substances of a chemical nature could be demonstrated in the expired breath. The common experience that a vitiated atmosphere is harmful has recently been explained by its increase in temperature and increase in humidity. Some sanitarians have gone so far as to state that if the temperature and moisture can be kept down and the air kept in motion, say, by an electric fan, it may be re-

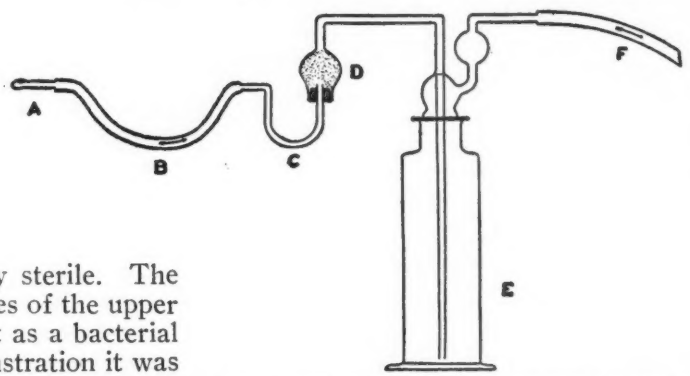

FIG. 1—METHOD A FOR SECURING SAMPLES OF EXPIRED AIR

A. Mouth-piece.
B. Rubber connection.
C. Trap.
D. Filter of glass wool.
E. Drexel bottle which stands in an ice and salt freezing mixture.
F. Rubber connection to vacuum pump.

breathed. To this view the writers cannot subscribe, for they have always felt that a vitiated air must contain substances which are harmful even though not demonstrable to science.

EXPERIMENTS ON MICE TO SHOW PRESENCE OF ORGANIC MATTER IN VITIATED AIR

In 1863 Hammond demonstrated the presence of organic matter in vitiated air by experiments upon mice and also by passing the air vitiated by respiration thraugh potassium permanganate. He confined a mouse under a large jar in which the carbon dioxide was taken up by baryta water as fast as it was formed and the moisture absorbed with calcium chloride. Nevertheless the mouse died in forty minutes. The observation was repeated a number of times and death ensued invariably in less than one hour. Brown-Séquard and D'Arsonval condensed the moisture in the exhaled breath, and the liquid thus collected was injected into the veins of rabbits. Death usually took place in a few days; sometimes in a few weeks. They believed from this that they had discovered a volatile organic poison of the nature of an alkaloid similar to Brieger's ptomaines.

These experiments were repeated with variable results, but in 1889 they reported ingenious experiments in which they obtained additional evidence in support of their former statements. Rabbits were confined in a series of jars connected with rubber tubing permitting a constant current of air to be passed. The animal in the last jar received the air from the lungs of the animals in the other jars. This animal died after an interval of some hours and the animal in the next died next. The first and second animals usually remained alive.

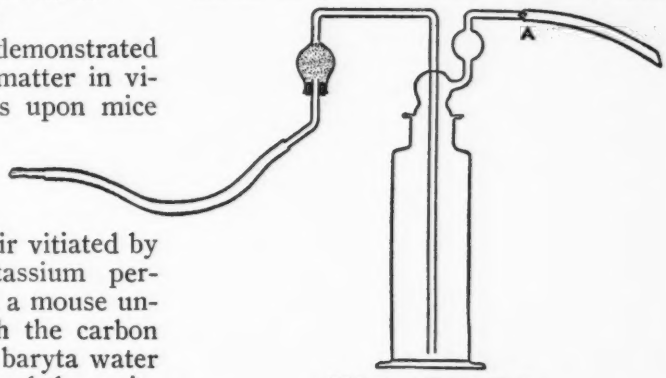

FIG. 2—METHOD B

Similar in all respects to Method A, excepting the form of trap, and an additional cotton filter at A, to prevent contamination from the outlet of the Drexel bottle. As a further guard against contamination, the neck of the Drexel bottle in this and all subsequent methods was swathed with several layers of sterile gauze.

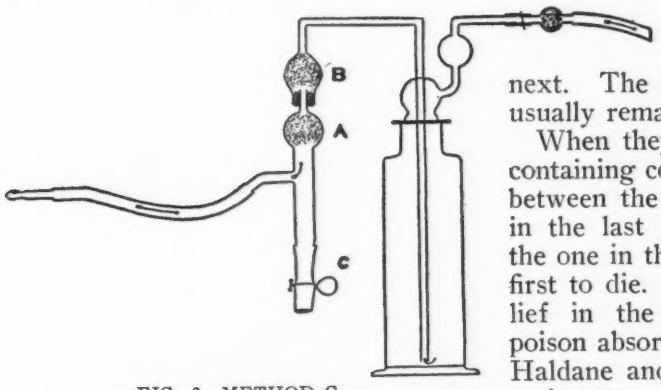

FIG. 3—METHOD C

The apparatus in this method contained two glass-wool filters, A and B, and an improved trap controlled with a Mohr's pinchcock. The bulbs A and B were surrounded with a box warmed with a 16-candle power electric globe and the temperature controlled by a thermometer between 37° and 40° C.

When they placed absorption tubes containing concentrated sulphuric acid between the last two jars the animal in the last jar remained alive while the one in the jar just before was the first to die. This confirmed their belief in the existence of a volatile poison absorbed by the sulphuric acid. Haldane and Smith repeated the experiments of Brown-Séquard and D'Arsonval, using five bottled mice. They continued the exposure for 53 hours without ill-effects to the mice. Beu, in 1893, also repeated these experiments and came to the conclusion that acute poisoning through the organic matters contained in the expired air was not possible and that the death of the animals was due to changes

of temperature and accumulation of moisture in the jars. Bauer, in 1893, also Lübberd and Peters, concluded from similar experiments that there are no organic poisons in the expired air.

INOCULATION OF ANIMALS WITH CONDENSED FLUID FROM HUMAN BREATH

Lehmann and Jessen, in 1890, collected from 15 to 20 cu. cen. of condensed fluid per hour from the breath of a person exhaling through a glass spiral laid in ice. This fluid was always clear, odorless, neutral in reaction and contained slight traces of ammonia from persons with good teeth; more from those with poor teeth. Inoculation of this condensed fluid into animals gave negative results. In 1894, Brown-Séquard and Davis reported further experiments in which they inoculated over 100 animals with the condensed fluid of respiration and not only confirmed their former statements, but were unable to understand the failure of other experiments, and emphatically reaffirmed that the breath contains a volatile poison and that the death of animals under experimental conditions is not due to an excess of carbon dioxide nor a deficiency of oxygen. This question was studied by Billings, Mitchell and Bergey in 1895, who came to the conclusion that the ill-effects of a vitiated atmosphere depend almost entirely upon increased temperature and moisture, and not to an excess of carbon dioxide or bacteria or dust of any kind.

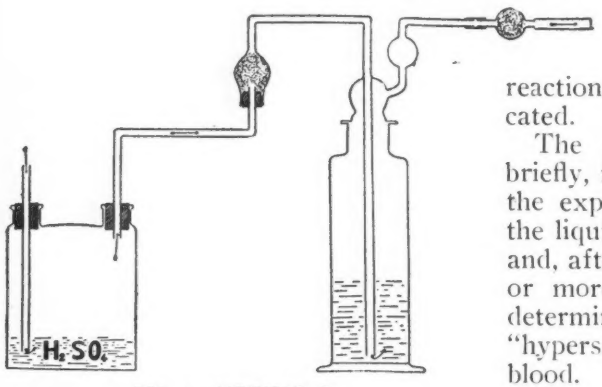

FIG. 4—METHOD D

APPARATUS USED FOR THE EXPERIMENTS WITH MILK

The air was first passed through a Woulf's bottle containing concentrated sulphuric acid, then filtered through glass-wool and bubbled through the milk in the first Drexel bottle and the vapors thus collected were condensed in a second Drexel bottle not shown in the diagram.

ARRANGEMENT OF PRESENT TESTS

It will be seen from this brief review that this question of the presence of organic matter in the expired breath is in confusion.

The present experiments were taken up in order to demonstrate, if possible, the presence of organic matter in the expired breath by means of the reaction of anaphylaxis. It is now generally recognized that the reaction of anaphylaxis is exceedingly delicate, for by its means we are enabled to distinguish so small a quantity as 1/1,000,000 cu. cen. of blood serum or 1/20,000,000 of a gram of purified egg-white—amounts far too small to detect by any chemical method. The reaction of anaphylaxis has the further advantage of being specific, so that if organic matters are found through this reaction their nature may be predicated.

The method adopted consisted, briefly, in condensing the vapors from the expired breath of man, injecting the liquid so obtained into guinea-pigs and, after an interval of several weeks or more, testing the guinea-pigs to determine whether they have become "hypersusceptible" to normal human blood.

The fact that the guinea-pigs showed a definite response clearly indicates that they were sensitized with a protein substance of human origin. This statement is based upon the fact now well established, that guinea-pigs may be sensitized only with albuminous matter higher in structure than peptones, and the specific nature of the phenomenon makes it reasonably certain that the protein matter in this case must have been of human origin.

At first sight it seems almost incredible to believe that such a complex molecule as protein may be volatile.

Nevertheless, such appears to be the natural conclusion to draw from the results of our experiments. After all, the question of volatility may have much similarity to the question of solubility. Theoretically, all substances are soluble, although some in minute amounts; in the same sense all substances may be volatile. Volatility does not mean necessarily a change to the gaseous state in the sense that simple substances are volatile. Thus we may assume that solid and liquid substances may pass into the air in a state of "colloidal suspension." The simplest conception would be to regard the protein as passing off in solution in the watery vapor. Whatever the physico-chemical conception, the inference is forced upon us that protein may pass into the air in the expired breath and be again collected in sufficient amounts to produce a definite biological reaction in susceptible animals.

The fact that organic substances, specific in nature, have been definitely demonstrated in the expired breath does not prove that these substances are poisonous. The physiological effect of such organic matter must now be studied.

SUMMARY AND DISCUSSION

Through the reaction of anaphylaxis the presence of organic matter has been demonstrated in the expired breath.

Ninety-nine guinea-pigs were tested in 25 different experiments. Of the 99 guinea-pigs 26 gave definite symptoms of anaphylaxis; this does not include the animals showing suggestive or mild symptoms. In four of the animals the reaction was so severe that death ensued from anaphylactic shock.

The expired breath of eight persons was tested; of these five gave positive reactions; upon each of the remaining three only one experiment was made.

This organic matter must, according to the interpretations of our knowledge of anaphylaxis in the guinea-pig, be protein in nature.

Further, this protein substance is specific and for the present it is assumed to come from the blood.

The indications are that this organic matter is probably present in variable amounts, although the reaction is a qualitative and not a quantitative test.

The fact that a number of the experiments resulted negatively may mean either that the organic matter is present in the expired air in exceedingly small amounts or that the guinea-pigs with which we worked did not come from a very sensitive race. There are indications which suggest that the expired breath from certain

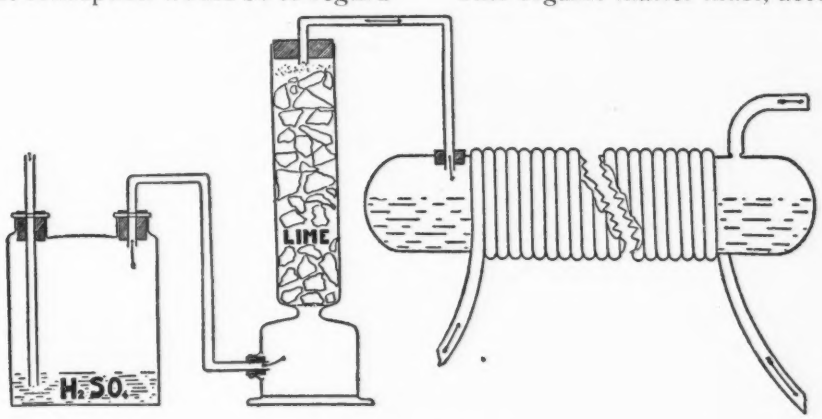

FIG. 5—METHOD E

METHOD USED IN THE EXPERIMENTS WITH EGG AND BLOOD

The air was first dried, being passed through concentrated sulphuric acid in a Woulf's bottle and then through a tower containing lime. The dried air was conducted over the surface of the eggs or the blood in a horizontal glass tube 3 inches in diameter and 3 feet long, thence to a Drexel bottle (not shown in the diagram) standing in a freezing mixture, where the moisture was condensed. The horizontal tube was surrounded with a coil of rubber tubing through which was circulating warm water at 37° C.

persons contains more organic matter than from other persons; also that the amount varies with conditions. The writers obtained a greater percentage of reactions in the guinea-pigs injected with the liquid condensed from the expired breath of females than those injected with the liquid condensed from the expired breath of males. Whether this is a mere coincidence or not may be determined only by collecting more extensive data.

A few experiments were recorded to determine the effect of time, temperature, acids and alkalies upon the organic matter in the expired breath, but the data are too limited to draw conclusions. It is of practical importance to collect further information along these lines. It would also be interesting to study the organic matter in the expired breath in health and disease; in different ages, etc.

SALIVA CONTROL

One possible source of error was kept in mind throughout these experiments, that is, that particles of saliva might pass the barrier of the cotton wool and appear in the condensed liquid. If guinea-pigs can be sensitized with saliva the least fault in technic in this regard would render the results misleading. Every precaution was taken to prevent this accident. The bulbs were tightly stuffed with glass wool and the fact that bacteria did not get through is a fair indication that other particulate matter did not pass.

It becomes important to know whether guinea-pigs sensitized with saliva will respond after a proper interval to a second injection of human blood serum.

In some of the experiments the guinea-pigs were given a first injection of an amount of saliva far in excess of any quantity that could possibly have been contained in the liquid condensed from the expired breath under the conditions of our experiments. At the second injection they were given normal human serum in the same amounts and by precisely the same methods used to demonstrate the presence of organic matter in the expired breath.

The guinea-pigs injected with human saliva gave practically no response to a second injection of human blood serum.

A comparatively large number of the guinea-pigs inoculated subcutaneously with the condensed liquid from the expired breath developed sloughs at the site of the injection. It is not certain whether this was due to the presence of the relatively large amounts of liquid injected or to some irritating principle contained in the liquid. Occasionally the local effects may have been due to the fact that the liquid was cold when injected. The injection of the condensed liquid caused no other untoward symptoms upon the animals, which is quite contrary to the observation upon rabbits of Brown-Séquard and others.

The best results were obtained when the second injection was given directly into the heart. With a little practice this operation upon the guinea-pigs is easily performed and unattended with any ill-effects.

The logical conclusion from the results of these tests is that protein substances under certain circumstances may be volatile. It seems unlikely that such a complex molecule should possess the power of passing into the air in a gaseous form. The volatility, however, now in question may resemble that solubility which deals with particles in suspension in a physico-chemical state (colloidal suspension). The protein may simply be carried over in "solution" in the watery vapor.

The experiments are too few to state that albuminous substances such as egg-white, milk, or blood serum in vitro is "volatile." However, they are sufficiently suggestive to stimulate further work along this line.

ORGANIC MATTER NOT NECESSARILY POISONOUS

The fact that organic matter is present in the expired breath does not mean that these substances are poisonous. The physiological effects should now be studied. It is evident, however, that the air contains many substances which we cannot at present discern, some of which may have an

important bearing upon health. Thus it is well known that most of the cases of sudden death following the first injection of horse serum (diphtheria antitoxin) occur in adults. Children rarely give a severe immediate reaction at the first injection. How the adults become sensitized has always been a mystery. It may now be assumed that some susceptible persons may absorb, through the lungs, enough horse protein, from close association with horses, to become sensitized. This hypothesis will be tested by exposing guinea-pigs to the expired breath of horses and then testing their power of reaction to horse serum. The expired breath of other animals will be similarly tested and the condensed breath of animals other than man will also be studied.

The fact that the expired breath contains definite amounts of specific organic substances will also have an immediate bearing upon the problems of ventilation and the effects of vitiated air. There has recently been a growing tendency to regard the ill-effects of vitiated air as due to the increased temperature and moisture, but it is now apparent that there are other factors which must be taken into account.

Review of Heating Literature

EDITOR'S NOTE.—*This is the second of a series of articles reproduced from former issues of* THE HEATING AND VENTILATING MAGAZINE. *These articles are here presented in response to a steady demand for the back numbers which contained them, but which were long since out of print. The first article, in the November issue, was entitled, "Greenhouse Heating Charts," by John A. Payne.*

II.—CROSS-SECTIONS OF CHIMNEYS

BY C. C. MULFORD

From the many widely varying rules for finding the cross-section of a chimney per height of same when horse power is given, it is difficult to fix upon any one, as "one man's food seems to be another's poison." Therefore, I give the following rule and table, based upon my practical experience as the one I have found to fill all wants. Assuming that every reader knows that the difference between the temperature of the gases in the chimney and that of the outside or surrounding air is the cause by which draft is effected, it will not be necessary to use up space and time by going into it to any great extent.

As air expands 0.002 of its volume for every degree it is raised above 32° F., the chimney must be made to conform to the demands for space. This can be done in two ways: first, by increasing the cross-section area; second, by increasing the height, which gives greater velocity and thus takes care of the increased volume, the latter being the more practical one.

The economical flue for a dwelling house should have a velocity not to exceed from 5 to 7 ft. per second. This may be had in flues or chimneys, say, from 38 to 40 ft. high by an increase of temperature from 10° to 12° above the outside air.

Tredgold's rule for chimneys for steam boilers is as follows: "The area of a chimney in inches for a low pressure steam engine, when above 10 H. P., should be 112 times the horse power of the engine, divided by the square root of the height of the chimney in feet.

"*Example:* Required area of a chimney for an engine of 40 H. P. its height being 70 ft. In this case

$$\frac{40 \times 112}{\sqrt{70}} = 533.2 \text{ sq. in.}"$$

In another place Mr. Tredgold advises that chimneys be built double the size called for by this rule. In that event the chimney would contain 1066.4 sq. in. or about 7½ sq ft.

Horse-power	Height of Chimney, in Feet																																
	38	44	50	56	60	65	70	75	80	85	90	95	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
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5	72	66	64	64	64	64	64	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
6	84	79	74	70	68	65	63	60	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
7	101	92	87	82	79	76	73	71	68	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8	115	107	99	94	90	87	84	82	79	77	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
9	130	118	111	105	101	97	94	90	87	86	83	81	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
10	144	131	123	117	112	108	104	100	97	96	92	89	87	83	79	76	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
12	173	157	148	140	134	130	125	121	117	115	110	107	104	99	94	91	88	86	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
14	220	186	173	163	157	151	146	142	136	134	129	125	121	116	110	106	102	101	95	....	....	....	....	....	....	....	....	....	....	....	....	....	....
16	230	210	197	187	180	173	167	161	155	154	147	143	138	131	124	121	118	113	109	....	....	....	....	....	....	....	....	....	....	....	....	....	....
18	247	236	226	210	202	195	187	181	175	173	166	160	151	148	141	137	132	131	119	....	....	....	....	....	....	....	....	....	....	....	....	....	....
20	288	266	248	247	224	216	208	202	194	192	184	178	173	165	157	152	142	144	136	....	....	....	....	....	....	....	....	....	....	....	....	....	....
25	356	332	308	292	282	270	260	251	244	240	230	222	216	206	197	189	183	180	170	....	....	....	....	....	....	....	....	....	....	....	....	....	....
30	435	392	370	350	338	324	312	301	291	288	276	257	260	247	236	227	220	216	220	....	....	....	....	....	....	....	....	....	....	....	....	....	....
35	550	459	432	410	393	378	364	352	340	336	322	312	302	288	275	265	256	252	238	....	....	....	....	....	....	....	....	....	....	....	....	....	....
40	....	....	495	467	450	432	417	402	388	385	368	356	346	329	314	303	293	288	272	266	258	....	....	....	....	....	....	....	....	....	....	....	....
45	....	....	557	525	505	486	469	452	438	433	414	400	389	370	354	342	333	324	306	299	290	....	....	....	....	....	....	....	....	....	....	....	....
50	....	....	617	584	562	540	520	503	485	480	460	445	432	412	393	379	366	360	340	332	322	....	....	....	....	....	....	....	....	....	....	....	....
55	....	....	680	642	617	594	572	552	534	527	505	490	475	452	432	417	402	396	374	366	354	....	....	....	....	....	....	....	....	....	....	....	....
60	....	....	740	700	672	648	624	603	582	575	550	535	520	494	472	455	440	432	407	398	387	....	....	....	....	....	....	....	....	....	....	....	....
65	....	....	802	760	730	702	675	652	631	625	598	580	562	535	510	492	476	467	442	432	419	....	....	....	....	....	....	....	....	....	....	....	....
70	....	....	862	817	785	755	730	705	680	672	642	625	605	575	550	531	512	504	477	465	452	....	....	....	....	....	....	....	....	....	....	....	....
75	....	....	925	875	840	810	782	752	727	720	690	663	648	617	590	568	550	540	510	499	484	....	....	....	....	....	....	....	....	....	....	....	....
80	....	....	987	934	897	865	831	803	777	767	736	710	692	658	627	606	590	576	544	532	516	....	....	....	....	....	....	....	....	....	....	....	....
85	....	....	1026	999	955	917	885	855	825	816	781	757	735	700	667	645	622	612	578	565	548	....	....	....	....	....	....	....	....	....	....	....	....
90	....	....	1123	1051	1016	972	936	904	875	864	825	800	777	740	707	682	660	648	612	597	580	....	....	....	....	....	....	....	....	....	....	....	....
95	....	....	1170	1108	1007	1003	999	955	922	912	875	846	827	782	746	720	696	684	647	636	612	....	....	....	....	....	....	....	....	....	....	....	....
100	....	....	1235	1166	1123	1080	1040	1005	970	960	922	890	865	822	786	757	732	720	680	665	645	....	....	....	....	....	....	....	....	....	....	....	....
105	....	....	1296	1225	1178	1118	1090	1055	1020	1009	965	936	907	865	825	796	768	756	715	697	677	657	648	....	....	....	....	....	....	....	....	....	....
110	....	....	1353	1254	1238	1119	1115	1105	1007	1055	1010	980	950	905	865	834	805	792	740	732	710	689	679	....	....	....	....	....	....	....	....	....	....
115	....	....	1411	1340	1290	1240	1200	1150	1102	1100	1006	1002	995	945	902	870	840	828	782	764	741	720	710	....	....	....	....	....	....	....	....	....	....
120	....	....	1483	1400	1345	1295	1250	1205	1155	1150	1102	1070	1038	987	942	910	880	865	816	797	774	752	740	....	....	....	....	....	....	....	....	....	....
125	....	....	1541	1451	1400	1350	1300	1250	1210	1200	1150	1115	1080	1041	982	947	915	900	850	830	806	782	791	....	....	....	....	....	....	....	....	....	....
130	....	....	1650	1518	1451	1410	1352	1305	1251	1253	1195	1159	1122	1065	1021	985	950	937	885	865	837	815	802	....	....	....	....	....	....	....	....	....	....
135	....	....	1665	1570	1512	1451	1405	1355	1310	1298	1240	1201	1166	1109	1051	1022	999	972	920	897	870	845	824	....	....	....	....	....	....	....	....	....	....
140	....	....	1728	1635	1570	1510	1450	1405	1339	1342	1287	1248	1210	1150	1094	1051	1022	1008	952	930	902	877	864	....	....	....	....	....	....	....	....	....	....
145	....	....	1790	1691	1630	1562	1510	1452	1408	1390	1330	1290	1252	1195	1137	1094	1051	1037	987	962	935	907	895	....	....	....	....	....	....	....	....	....	....
150	....	....	1850	1750	1656	1620	1560	1509	1452	1440	1380	1335	1295	1234	1152	1178	1094	1076	1019	997	967	940	925	....	....	....	....	....	....	....	....	....	....
155	....	....	1915	1810	1740	1672	1615	1568	1502	1488	1425	1380	1340	1267	1210	1166	1135	1108	1054	1022	1000	970	957	....	....	....	....	....	....	....	....	....	....

CROSS-SECTIONAL AREA OF CHIMNEYS, IN SQUARE INCHES, FOR VARIOUS HEIGHTS AND HORSE-POWERS

Horse-power	Height of Chimney, in Feet																															
	38	44	50	56	60	65	70	75	80	85	90	95	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
160	....	....	1975	1870	1795	1730	1665	1608	1552	1535	1470	1425	1382	1329	1253	1210	1166	1152	1080	1065	1036	1000	988	....	....	....	....	....	....	....	....	....	....
165	....	....	2020	1925	1850	1780	1720	1658	1600	1585	1518	1470	1425	1353	1296	1252	1209	1189	1135	1095	1066	1045	1020	....	....	....	....	....	....	....	....	....	....
178	....	....	2100	1985	1910	1835	1770	1710	1750	1630	1565	1518	1444	1400	1335	1290	1245	1225	1158	1130	1097	1065	1005	1012	992	980	948	....	....	....	....	....	....
175	....	....	2160	2042	1962	1890	1820	1755	1700	1680	1610	1560	1515	1444	1372	1328	1280	1260	1190	1162	1130	1098	1080	1042	1022	1009	975	....	....	....	....	....	....
180	....	....	2221	2100	2010	1945	1875	1810	1750	1730	1652	1602	1555	1483	1415	1365	1320	1298	1225	1198	1160	1128	1111	1072	1050	1038	1002	....	....	....	....	....	....
185	....	....	2280	2160	2080	2000	1930	1860	1795	1775	1700	1635	1600	1522	1451	1400	1355	1332	1259	1230	1202	1160	1042	1102	1080	1064	1031	....	....	....	....	....	....
190	....	....	2342	2220	2124	2065	1980	1910	1840	1820	1760	1695	1642	1565	1492	1440	1392	1390	1292	1262	1225	1190	1172	1132	1110	1095	1060	....	....	....	....	....	....
195	....	....	2405	2280	2245	2102	2015	1960	1895	1870	1795	1740	1685	1603	1530	1478	1428	1405	1328	1295	1258	1220	1205	1162	1138	1122	1088	....	....	....	....	....	....
200	....	....	2470	2330	2240	2160	2080	2005	1940	1920	1838	1780	1730	1648	1570	1515	1462	1440	1360	1330	1290	1252	1235	1192	1168	1151	1115	....	....	....	....	....	....
210	....	....	2590	2441	2348	2270	2190	2158	2018	2008	1930	1870	1815	1730	1650	1591	1538	1511	1430	1395	1352	1315	1295	1250	1225	1210	1170	....	....	....	....	....	....
220	....	....	2710	2570	2470	2380	2290	2101	2178	2101	2010	1960	1901	1810	1730	1670	1610	1585	1500	1461	1420	1378	1358	1310	1285	1268	1228	....	....	....	....	....	....
230	....	....	2828	2680	2568	2482	2385	2305	2215	2202	2108	2042	1989	1891	1805	1742	1685	1658	1565	1529	1482	1440	1420	1370	1342	1325	1282	....	....	....	....	....	....
240	....	....	2960	2800	2649	2585	2500	2405	2315	2302	2202	2120	2068	1975	1885	1820	1758	1729	1632	1595	1548	1502	1480	1430	1400	1382	1338	....	....	....	....	....	....
250	....	....	3080	2910	2801	2700	2602	2504	2412	2400	2300	2215	2160	2060	1964	1895	1830	1800	1700	1661	1611	1565	1542	1490	1460	1440	1392	1368	1350	1315	....	....	....
260	....	....	3205	3020	2920	2810	2710	2605	2510	2498	2385	2308	2250	2120	2020	1970	1905	1872	1770	1730	1675	1630	1605	1550	1518	1500	1450	1421	1405	1370	....	....	....
270	....	....	3340	3150	3000	2918	2810	2708	2610	2590	2480	2410	2318	2220	2120	2024	1975	1945	1838	1795	1740	1691	1668	1610	1575	1555	1505	1475	1460	1420	....	....	....
280	....	....	3460	3270	3120	3021	2908	2808	2710	2682	2565	2488	2420	2302	2200	2120	2045	2018	1905	1860	1805	1755	1730	1670	1635	1612	1561	1530	1510	1475	....	....	....
290	....	....	3580	3380	3250	3130	3020	2910	2810	2790	2660	2580	2510	2390	2280	2200	2120	2090	1975	1930	1870	1825	1790	1730	1692	1670	1615	1585	1515	1530	....	....	....
300	....	....	....	....	....	3220	3110	3009	2905	2880	2760	2668	2548	2465	2360	2268	2200	2160	2040	1995	1935	1880	1850	1788	1750	1730	1672	1640	1620	1580	....	....	....
310	....	....	....	....	....	3320	3210	3108	3000	2969	2822	2760	2680	2550	2428	2350	2270	2238	2110	2006	2000	1940	1915	1848	1810	1785	1730	1695	1672	1630	....	....	....
320	....	....	....	....	....	3448	3322	3230	3110	3070	2940	2850	2760	2628	2518	2422	2341	2300	2168	2121	2060	2000	1975	1910	1815	1840	1780	1750	1725	1685	....	....	....
330	....	....	....	....	....	3562	3450	3320	3210	3170	3030	2920	2845	2712	2590	2500	2408	2380	2221	2190	2130	2064	2020	1965	1930	1900	1840	1805	1780	1750	....	....	....
340	....	....	....	....	....	3685	3540	3420	3300	3260	3130	3022	2940	2800	2681	2590	2490	2450	2318	2260	2190	2130	2100	2003	1859	1960	1895	1860	1835	1790	....	....	....
350	....	....	....	....	....	3780	3640	3510	3400	3360	3250	3120	3020	2880	2745	2650	2560	2520	2380	2320	2260	2190	2160	2090	2041	2030	1950	1912	1890	1845	....	....	....
360	....	....	....	....	....	3890	3750	3620	3500	3460	3310	3208	3110	2960	2830	2730	2640	2590	2450	2390	2320	2248	2220	2140	2100	2080	2008	1970	1945	1900	....	....	....
370	....	....	....	....	....	4000	3850	3720	3590	3525	3400	3300	3200	3020	2910	2800	2710	2660	2520	2460	2380	2820	2280	2200	2160	2130	2060	2020	2000	1950	....	....	....
380	....	....	....	....	....	4100	3960	3820	3686	3655	3500	3390	3280	3150	2980	2880	2780	2740	2580	2520	2445	2380	2340	2260	2220	2190	2120	2080	2050	2000	....	....	....
390	....	....	....	....	....	4200	4052	3920	3780	3740	3581	3480	3380	3210	3060	2960	2860	2810	2560	2598	2520	2440	2410	2320	2280	2242	2180	2130	2110	2060	....	....	....
400	....	....	....	....	....	....	4160	4020	3880	3840	3680	3560	3460	3300	3120	3030	2930	2880	2720	2660	2580	2500	2461	2370	2340	2300	2230	2190	2160	2110	2070	....	....
410	....	....	....	....	....	....	4275	4120	3980	3940	3770	3650	3540	3380	3220	3110	3000	2960	2790	2720	2640	2565	2530	2440	2400	2360	2280	2240	2240	2160	2120	....	....
420	....	....	....	....	....	....	4375	4220	4075	4040	3860	3740	3630	3460	3300	3180	3080	3022	2860	2800	2710	2630	2590	2500	2450	2420	2330	2300	2270	2218	2170	....	....
430	....	....	....	....	....	....	4475	4320	4175	4120	3950	3830	3720	3540	3380	3260	3150	3100	2920	2860	2770	2690	2660	2560	2510	2480	2400	2350	2320	2265	2220	....	....
440	....	....	....	....	....	....	4580	4425	4275	4224	4050	3920	3800	3620	3460	3340	3220	3170	3000	2920	2840	2760	2720	2620	2570	2540	2450	2410	2380	2320	2280	....	....
450	....	....	....	....	....	....	4675	4525	4375	4320	4148	4000	3890	3700	3530	3410	3300	3240	3060	2990	2900	2820	2780	2680	2630	2590	2510	2460	2370	2370	2330	2290	2248
460	....	....	....	....	....	....	4785	4625	4470	4425	4225	4100	3980	3780	3620	3490	3370	3318	3130	3060	2961	2880	2840	2740	2680	2650	2560	2518	2430	2420	2380	2340	2300
470	....	....	....	....	....	....	4900	4725	4550	4520	4325	4190	4070	3870	3700	3560	3440	3380	3200	3120	3030	2940	2900	2800	2740	2710	2620	2570	2540	2480	2430	2390	2340
480	....	....	....	....	....	....	5000	4825	4650	4600	4420	4275	4150	3950	3770	3640	3520	3460	3260	3190	3100	3000	2960	2860	2800	2780	2680	2620	2589	2525	2480	2440	2400
490	....	....	....	....	....	....	5100	4925	4750	4700	4510	4350	4248	4048	3850	3720	3590	3530	3340	3260	3160	3070	3020	2920	2860	2820	2730	2680	2650	2580	2540	2490	2450
500	....	....	....	....	....	....	5200	5025	4850	4800	4600	4450	4325	4120	3930	3790	3660	3600	3400	3320	3220	3130	3090	2980	2920	2880	2790	2740	2700	2640	2590	2540	2500
510	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
520	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

CROSS-SECTIONAL AREA OF CHIMNEYS, IN SQUARE INCHES, FOR VARIOUS HEIGHTS AND HORSE-POWERS

Milne's rule is the same as Tredgold's, only in place of 112 he uses 280. *Example:*

$$\frac{40 \times 280}{\sqrt{70}} = 1350 \text{ sq. in.}$$

or 9 54/144 sq. ft.

Murray's rule—18 sq. in. for 12 lbs. of coal.

From Box on Heat—H. P. 42.3, size of chimney at top, 2 ft.; height, 80 ft.

From Babcock & Wilcox—H. P. 41, height of chimney 70 ft.; actual square feet, 2.41.

The writer—40 H. P.; height of chimney, 70 ft.; 417 sq. in., or 2.9 sq. ft.

Rule of thumb is that the size of the flue should be equal to the area of all the tubes.

Another rule for chimneys for horizontal flue boilers is that the chimney should be from 60 to 80 ft. high, and have an area equal to half the square of the diameter of one of the tubes multiplied by the number of tubes.

I have stated only a few, but, I think, enough to show what a variety there is for one to choose from.

The accompanying table is compiled from the following rule: The area of a chimney in feet when above 10 H. P. should be 0.6 times the horse power divided by the square root of the height of the chimney in feet. *Example:*

$$\frac{40 \times 0.6}{\sqrt{70}} = 2.9 \text{ sq ft.}$$

This should be reduced to square inches, as the table is in square inches.

Centrifugal Fan Testing

By G. L. Copping

Interesting comments on methods of testing centrifugal fans, as well as the particulars of a test with a fan of this type delivering air at a medium pressure, are contained in a paper read by G. L. Copping, of London, at the October, 1911, meeting of the (British) Institution of Heating and Ventilating Engineers. The author emphasized the effect which a very slight variation in the shape of the blades has upon the capacity of a fan, a practically unnoticeable alteration of their angles to the radii—which might be due to careless fitting—being enough to alter the mechanical efficiency by 5% or more.

The chief data to be ascertained by testing were explained, together with the apparatus which, in the author's opinion, were most reliable for testing purposes, including the instruments available for measuring air speeds, either mechanical recorders or hydraulic recorders, chief among the first class being the anemometer.

Experience, however, shows that an error up to about 30% of the air speed might exist with this instrument, although it might be apparently in perfect order. Therefore, frequent calibration is necessary with this as well as all types of instruments belonging to the same class. Instruments of the hydraulic recorder class contain no moving parts excepting the liquid used, so that many errors which affected mechanical recorders are absent. But even here there are certain sources of error, the chief of which are capillarity of the liquid and errors in the design of the instrument which is placed in the air current to transmit the pressure to the liquid. To overcome the first-mentioned trouble, alcohol is the liquid usually employed. The second cause of error, however, necessitated much experimental work before a satisfactory instrument was obtained.

PRELIMINARY PROBLEMS REQUIRING SOLUTION

The problems which had to be solved were, first, how to measure accurately the static pressure of the air, without the speed of the air influencing the reading; and, second, how to measure the air speed correctly. The

author referred to some exhaustive tests recently made in Berlin by Dr. Brabbee by means of an instrument constructed of Pitot tubes, and this he proceeded to describe; passing on to another form of apparatus for converting air pressure into liquid pressure, and known as the micromanometer—the invention of R. Fuess, of Berlin.

As to the method of driving and of obtaining the net power taken by the fan itself, the author said many different arrangements had been tried with more or less accurate results. If it was more convenient to drive it by belt from line shafting, a spring coupling might be inserted between the fan spindle and the spindle upon which the driven pulley was mounted.

Arrangements could be made to measure the compression of the springs in the coupling when the fan was running, and from these measurements and the revolutions made by the coupling the power transmitted to the fan spindle could be calculated. The more usual method, however, is to drive the fan by a direct-coupled electric motor. The power developed by the electric motor may be obtained in three ways:

THREE METHODS OF DETERMINING POWER DEVELOPED BY MOTOR

(1) By calculation from the electric power supplied to the motor while driving the fan, and running under no load, and from the characteristic of the motor.

(2) By calculations made from tests with a Prony or other brake while the motor is running at the same speed and taking the same electric power as when driving the fan.

(3) By direct measurement of the torque between the motor armature and field, and calculation involving this torque and the revolutions.

In the author's opinion the third method is the most reliable and the most convenient for obtaining correctly the net power taken by the fan.

The bearings in which the armature turned, rested in ball bearings so that the motor field or casing was free to revolve. One end of a lever was screwed into the casing and a scale pan hung from the other. A short-weighted lever was screwed into the opposite side of the motor to counterbalance the above-mentioned lever and scale pan, so that when there was no current running through the motor, the latter was balanced and had no tendency to revolve either way. When the current was switched on, just sufficient weights were placed in the scale pan to balance the torque between the armature and field. The torque could then be calculated from the total weight added and the length of the lever. The horse-power developed by the motor was easily calculated from the torque and number of revolutions.

To ensure accuracy a plate with a line across it was screwed on top of the motor casing and a pointer fixed over this plate to a band passing over, but in no way attached to the motor. A microscope was also fixed to this band, by the aid of which the small deviations might be observed, and the weights in the scale pan adjusted until the line on the plate was immediately below the pointer.

A motor constructed and arranged in that manner was especially recommended for accurately obtaining small powers, although it is not so necessary for fans taking larger horse-power. By using a motor so arranged the accuracy of the power calculated does not depend upon the characteristic curve of the motor or any electric measurements.

ARRANGEMENTS FOR TEST

An illustration was submitted showing a fan under test with a sheet-iron duct connected to its outlet, in which duct the air measurements were taken by means of a double-pressure tube shown fixed in position passing through the side of the duct about halfway along its length. The frame at the end of the duct furthest from the fan carried a pair of sliding doors, with which the area of outlet from the duct could be regulated.

With reference to the arrangement of the fan and ducts, it is a question, the author stated, whether the air reading should be taken on the discharge side, feed side, or both sides of

the fan. Obviously the results obtained are influenced by the efficiency of the air inlet and outlet openings to and from the fan.

In Mr. Copping's opinion the best results can be obtained by connecting up both openings to ducts the same size as these openings, and measuring in both ducts.

The air inlet and outlet openings are then at the ends of the inlet and outlet ducts furthest from the fan, so that their influence on the capacity of the fan is recorded by the readings taken in the duct.

RESULTS OF TESTS

After illustrating and explaining certain methods of measuring the different pressures on the feed and discharge sides of a single inlet centrifugal fan, the author showed by plotted curves the efficiency of a 15-in. double-inlet Keith fan at any relationship between total water gauge and air-volume. The most interesting feature of the chart, he pointed out, was the shape of the total water-gauge curves. The variation of total water gauge from the average level of the curves was nowhere very great, from static non-delivery up to the largest volume. A slight fall was noticeable when the fan began to deliver air, after which it rose to its highest level at about maximum mechanical efficiency, and then fell at a constantly increasing angle, showing that the maximum mechanical and manometric efficiencies almost coincided, as was to be expected. The fall in total pressure referred to was found to take place with many differently designed centrifugal fans, but the subsequent rise was not so often met with.

Another interesting feature was the variation of mechanical efficiency with the speed of the fan. Although it was usual to assume that the power taken and total water gauge varied as the cube and square respectively, and the air volume directly as the fan speed, careful tests appeared to show that such assumptions were not strictly accurate. There appeared to be with each size and type of fan a certain speed at which it was possible to obtain a higher mechanical efficiency than at any higher or lower speed. From the tests with the Keith fan referred to, the most suitable speed seemed to be somewhere about 1600 R. P. M.

This feature offered scope for investigation, as it would be useful to know the causes which influenced this speed of highest efficiency, especially now that greater accuracy was required from fan makers in their capacity lists, and more economy in working was expected. When taking gauge readings it would usually be found that, whereas the readings across the horizontal width of the tube are fairly consistent, those taken down the vertical depth vary more or less. This seems to be due to incorrect construction of the fan casings, but investigation of this point would undoubtedly prove interesting. A further point requiring more study is the relative efficiencies of double and single-inlet fans. The author's own tests all went in favor of single-inlet fans, although this seemed the opposite to what would be expected.

German Ideas for Heating and Ventilation of School Buildings

At the meeting of the Congress for Heating and Lighting, held in Dresden, Germany, June 14 last, Schumacher, of Berlin, read a paper on the above topic, in which he laid down the following general principles:

(1) The normal temperature of class-rooms should be 18° C. = 64.4° F. at the height of the scholar's head; temperatures below 16° C. = 60.8° F. or above 20° C. = 68° F. are to be avoided.

(2) Where the arrangements are properly made, hot water or low-pressure steam is advisable.

(3) Where double sash is used, the radiators may be on the inner walls.

(4) Artificial ventilation is unques-

tionably necessary. The minimum amount permissible is thorough replacement of the entire volume of air every 20 minutes.

(5) Where the air for ventilation is cooler than that in the room, it must be equally distributed.

(6) Fan ventilation is preferable to any other system.

(7) Air outlets are necessary; but for pressure ventilation the outlets should provide for a maximum of half the amount of newly introduced air. Overhead outlets are necessary only when the lighting is by gas, or when there is no cooling by the introduction of cold air.

(8) Thorough ventilation of the class-rooms for some minutes in the pauses is recommended, even for schools with good ventilating appliances.

(9) Opening the windows during class-time is under no circumstances permissible.

(10) Appliances for moistening the air are absolutely unnecessary.

(11) Where there is no automatic apparatus to insure a regular temperature, attention to the radiators and ventilators should not be by teachers or scholars, but by employers. Such apparatus is highly recommended.

(12) In large cities, teachers of heating are necessary; who should see that the heating plants are properly attended to.

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*New Humidity Charts and Formulas**

By Willis H. Carrier

A specialized engineering field has recently developed, technically known as air conditioning, or the artificial regulation of atmospheric moisture. The application of this new art to many varied industries has been demonstrated to be of greatest economic importance. When applied to the blast furnace, it has increased the net profit in the production of pig iron from $0.50 to $0.70 per ton, and in the textile mill it has increased the output from 5% to 15%, at the same time greatly improving the quality and the hygienic conditions surrounding the operative. In many other industries, such as lithographing, the manufacture of candy, bread, high explosives and photographic films, and the drying and preparing of delicate hygroscopic materials, such as macaroni and tobacco, the question of humidity is equally important. While air conditioning has never been properly applied to coal mines, the author is convinced that if this were made compulsory, the greater number of mine explosions would be prevented.

Although of so much practical as well as scientific importance, the laws governing many of the phenomena of atmospheric moisture are but partially understood, while the present engineering data pertaining thereto are both inaccurate and incomplete. Accepted data used in psychrometric calculations are based largely on empirical formulæ, which are incorrect as well as limited in their range. Recent investigators have determined the most important properties of water vapor with final accuracy. At the same time, sufficient error has been shown in previous steam data, especially at atmospheric temperatures, to warrant the revision of all calculations based thereon.

It is the purpose of this paper to apply these final data to the development of rational formulæ for the solution of all problems pertaining to the phenomena of atmospheric moisture as related to psychrometry and to air conditioning. Original data are given in proof of fundamental relations as well as in determination of errors in standard psychrometric instruments. The author hopes these results may prove to be of permanent value.

*Condensed from a paper on "Rational Psychrometric Formulæ; Their Relation to the Problems of Meteorology and of Air Conditioning," read at the annual meeting of the American Society of Mechanical Engineers, New York, December 5-8, 1911.

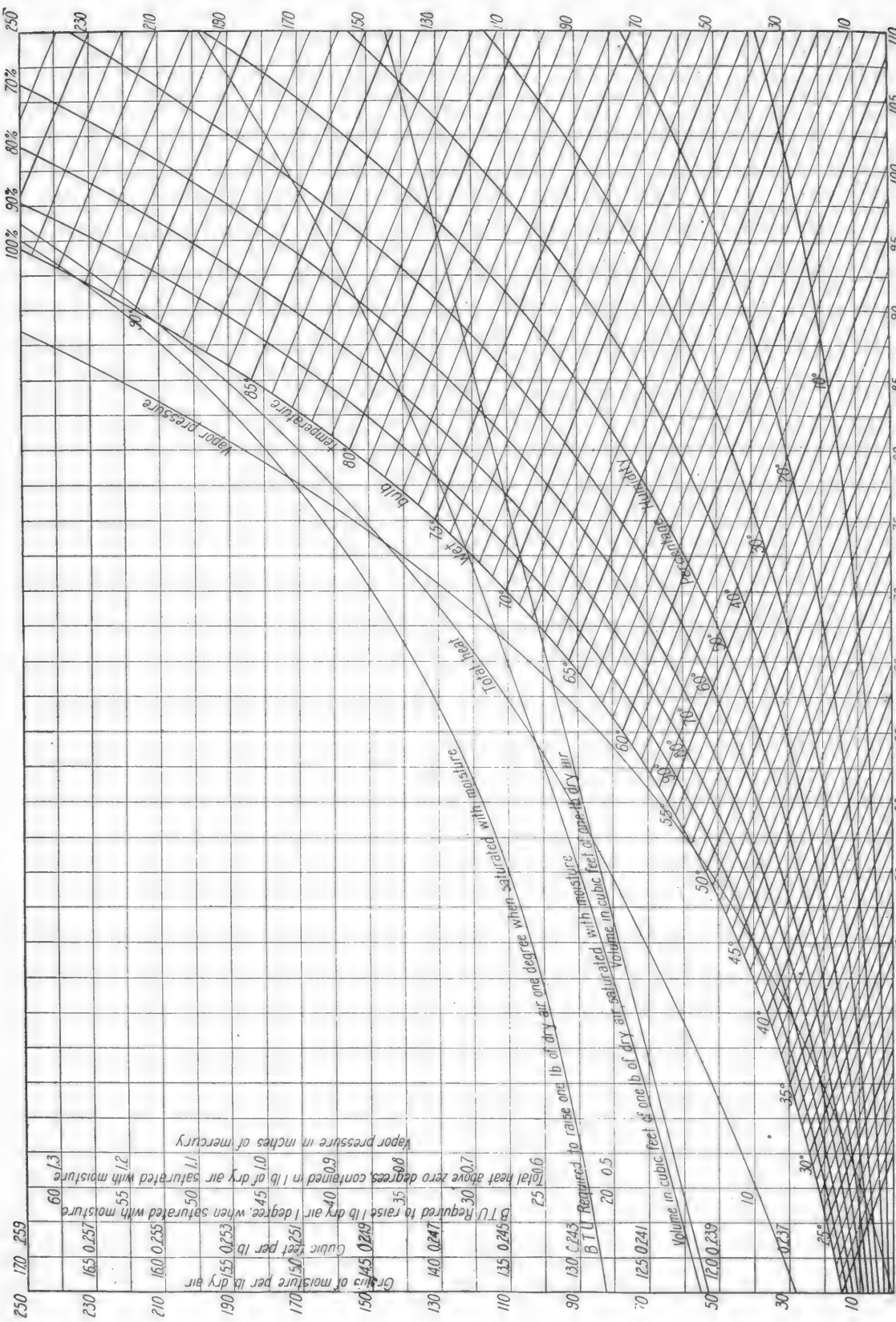
Vapor pressure
Temperature
Wet bulb
Total heat
Relative humidity
Grains of moisture per lb. dry air
Cubic feet per lb
B T U Required to raise 1 lb dry air 1 degree when saturated with moisture
Total heat above zero degrees contained in 1 lb of dry air saturated with moisture
Vapor pressure in inches of mercury
B T U Required to raise one lb of dry air one degree when saturated with moisture
Volume in cubic feet of one lb of dry air saturated with moisture
Volume in cubic feet of one lb of dry air
Dry bulb temperature

FIG. 1—PSYCHROMETRIC CHART

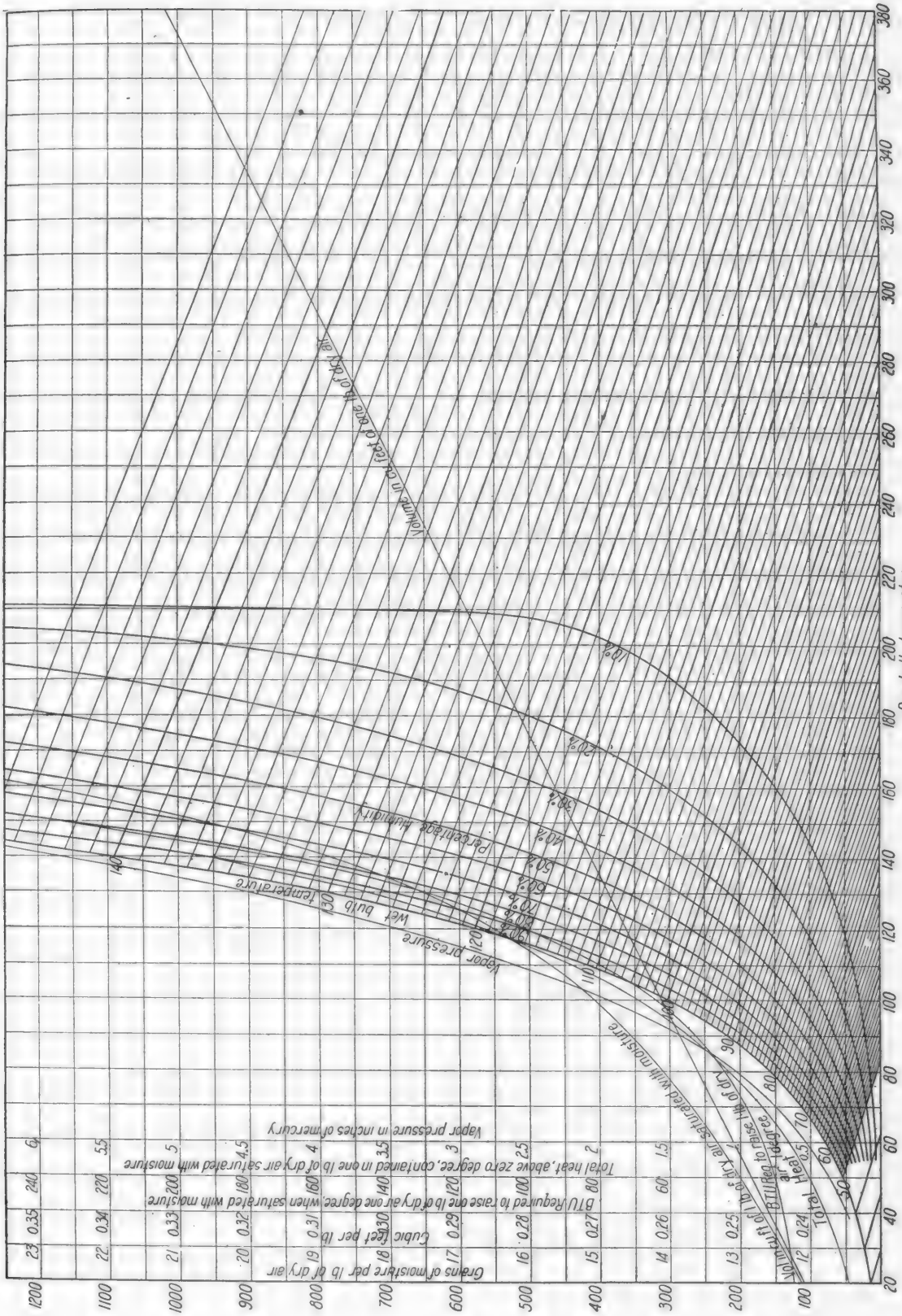
Dry-bulb temperature
Grains of moisture per lb of dry air
Cubic feet per lb
BTU required to raise one lb of dry air one degree, when saturated with moisture
Total heat, above zero degree, contained in one lb of dry air saturated with moisture
Vapor pressure in inches of mercury
Volume in cubic feet of one lb of dry air
Weight of one cubic foot of dry air
Volume of 1 lb of air saturated with moisture
BTU required to raise 1 lb of dry air 1 degree
Sensible heat
Total heat
Vapor pressure
Wet bulb temperature
Percentage humidity
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

FIG. 2—PSYCHROMETRIC CHART

VAPOR PRESSURE AND LAW OF PARTIAL PRESSURES

Water vapor exists in the air purely as a mixture in relation to its other elements. This vapor, according to Dalton's law, is capable of exerting a certain maximum vapor pressure dependent entirely on its temperature and regardless of the presence of other gases or vapors. For example, assume 1 cu. ft. saturated with vapor of alcohol at 100° C. having a vapor pressure of 1697.6 mm., and add isothermally to this 1 cu. ft. saturated with water vapor at 100° C. having a vapor pressure of 760 mm. This will give 1 cu. ft. of the mixture saturated with both water vapor and alcohol vapor at 100° C., having as a total pressure the sum of the two separate saturated vapor pressures, or 2457.6 mm. Similarly, an equal volume of a third saturated vapor might be added without affecting the other two. But if, on the other hand, it is attempted to include isothermally an additional amount of either of the saturated vapors, a corresponding condensation of the particular vapor added would result. In the same manner, an unlimited amount of a gas, such as air, could be added isothermally to a cubic foot of water vapor without affecting its condition of saturation, giving a combined pressure equal to the gas pressure plus the vapor pressure.

The established temperature-pressure relationship of saturated water vapor is shown on the charts, Figs. 1 and 2. This is the well-known temperature-pressure curve of steam.

PARTIAL SATURATION

When the temperature of a definite weight of saturated vapor is increased isobarometrically, it is said to be superheated. Its specific volume is increased, in accordance with the law of gases, in direct proportion to the increase of absolute temperature, while its density is changed in an inverse proportion — that is, $\frac{D_2}{D_1} = \frac{T_1}{T_2}$, where D_1 and D_2 are the densities corresponding to the absolute temperatures T_1 and T_2, respectively, and $(T_2 - T_1)$ is the degree of superheat. If D_2 is the density of saturated vapor at temperature T_2, then the ratio $\frac{D_2}{D_1}$ is said to be the per cent. of saturation, or, more exactly, the per cent. of isothermal saturation. When these relationships are considered with respect to water vapor in air, this ratio is termed the per cent. of relative humidity, while the densities D_1, D_2, D'_2, etc., customarily expressed in grains of moisture per cubic foot, are termed absolute humidities.

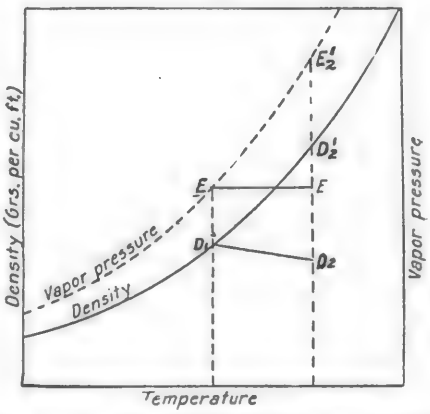

FIG. 3—TEMPERATURE-DENSITY DIAGRAM

DEW POINT

It should be noted that although the total weight of the water vapor remains the same, the absolute humidity D_2 is less than the absolute humidity D_1. However, if water vapor, or air containing water vapor, having a temperature T_2 and an absolute humidity of D_2, be cooled to T_1, it will become saturated, and if cooled further, moisture will be precipitated. Therefore, T_1 is termed the dew point of air having a temperature T_2 and an absolute humidity, D_2, or a corresponding relative humidity, $\frac{D_2}{D'_2}$. Therefore, the dew point may be defined as the minimum temperature to which air of a given moisture content may be cooled without precipitation of moisture.

Usually it is more convenient to

determine the absolute and relative humidities from the temperature-pressure curve by comparing the vapor pressures. The per cent. of humidity is $\frac{D_2}{D'_2}$, but it may also be shown to be equal to $\frac{e_1}{e'_2}$; i. e.,

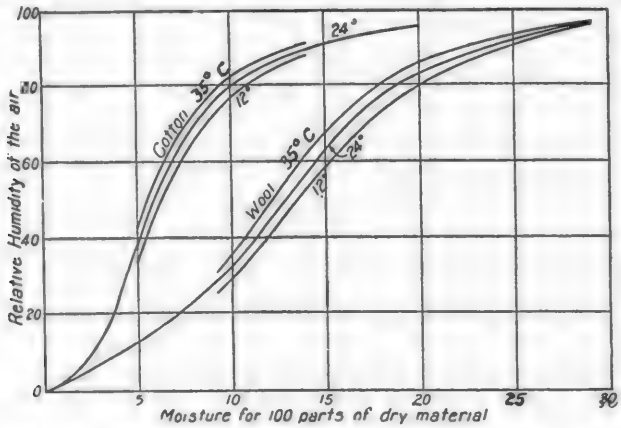

FIG. 4—EFFECT OF HUMIDITY ON MOISTURE CONTENT OF TEXTILES

$$\text{per cent. humidity} = \frac{e_1}{e'_2} = \frac{D_2}{D'_2} \ldots\ldots [1]$$

where e_1 is the pressure of saturated vapor corresponding to the dew point T_1, and e'_2 is the vapor pressure at saturation corresponding to temperature T_2. It also follows that

$$D_2 = D'_2 \times \frac{e_1}{e'_2} \ldots\ldots [2]$$

METHODS OF MEASURING ATMOSPHERIC HUMIDITY

Determinations of atmospheric moisture may be made by four distinct methods:

Chemical Method.—A measured quantity of air is drawn through some de-hydrating solution, such as concentrated sulphuric acid, until the moisture is completely removed and the increase in the weight of the solution noted.

Hygroscopic Method.—This method is chiefly useful in an approximate determination of the relative humidity directly. It is known that nearly all animal and vegetable substances containing albumen or cellulose, and also many mineral salts are very sensitive to changes in atmospheric moisture. The moisture content of such materials at equilibrium is found to bear a direct relation to the existing amount of moisture in the atmosphere.

The per cent. of moisture which they will freely absorb, however, is not exactly the same for the same percentage of humidity for different temperatures. This relationship of moisture content of various textiles to different atmospheric humidities and temperatures has been very thoroughly investigated by Schloessing in France.

It is, therefore, to be seen that the moisture content of the air will be approximately indicated by measuring the increase in weight of a skein of silk, or other textile, whose dry weight has been definitely determined. Such an instrument for the measurement of humidity has been devised by William D. Hartshorne, of Lawrence, Mass.

The action of the hair hygrometer depends upon its linear expansion, due both to humidity and temperature. The accuracy of this type of hygrometer was thoroughly investigated by Regnault. It may be calibrated to give a fairly accurate indication of humidity throughout a considerable range of temperature. However, the elasticity of the hair or any similar fiber is not permanent and any instrument operating on this principle requires frequent calibration and readjustment. Therefore, it can be used

only in connection with some instrument giving absolute determinations.

In his investigations of atmospheric humidity, Regnault found that a solution of calcium chloride exposed to the air would assume a density in proportion to the relative humidity. If the air became drier, it would evaporate moisture from the solution, increasing its density. If, on the other hand, the humidity of the air increased, moisture would be absorbed by the solution until it reached an equilibrium.

A test was made by the writer in May, 1902, to determine the moisture-absorbing properties of calcium-chloride brine for the purpose of air conditioning. It was found that with a constant humidity of the air, the rate of absorption varied directly in proportion to its change in density, and that the density of the solution decreased to a point where absorption stopped. In connection with this test an interesting phenomenon was observed relative to the conversion of the latent heat into sensible heat of the moisture thus absorbed. By measuring the increase in temperature, it was found possible to account very closely for the calculated latent heat of the moisture removed. The temperature of the solution was, furthermore, considerably higher than the final temperature of the air. This may be explained by the assumption that the absorption and consequent heat transformation occurred at the surface film where the air in the film and the liquid were heated to an equal temperature, and that not all of the air came into direct contact with the liquid. This is the direct inverse of phenomena occurring in evaportion with incomplete saturation. Here the temperature of the air is lowered to correspond with the increase in latent heat by evaporation, while the water always remains at a lower temperature than the partially saturated air.

In 1909, in connection with a test made upon a humidifying plant for conditioning tobacco, similar phenomena were noted. It was found that the ventilation of cool, dry tobacco with moist air produced a rapid rise in temperature both of the air and of the tobacco, which rose to a much higher temperature than the air.

Dew-Point Method.—The dew-point method was first brought into use by Daniels and by Regnault, and adopted by the United States Weather Bureau in the determination of the values used in their psychrometric tables. The dew point is measured directly by observing the temperature at which moisture begins to form upon an artificially cooled mirror surface. Determination by this method is extremely delicate, and when suitable precautions are taken is considered very accurate. However, it is questionable whether the true dew point is ever quite as low as indicated by this method.

Evaporative or Psychrometric Method.—The evaporative or psychrometric method has not heretofore, to the writer's knowledge, been definitely accepted as an absolute means of moisture determination, but, as will be demonstrated, is independent of and preferable to all other methods in scope and accuracy. It is of special interest in relation to the art of air conditioning, because the same fundamental phenomena are involved and subject to the same theory. It is of service not only in the art of air conditioning, but also a departure in the science of meteorology. It provides a method, remarkable for simplicity and accuracy, for the determination of the specific heat of air, which present methods have failed to establish, within an unquestioned accuracy of 2%.

This method of moisture determination depends upon the cooling effect produced by the evaporation of moisture in a partially saturated atmosphere. This is usually measured by covering the bulb of an ordinary mercurial thermometer with a cloth or wick saturated with water and comparing its temperature with that of a thermometer unaffected by evaporation. The covered bulb is termed the wet-bulb thermometer, and the difference between the wet and dry-bulb readings is termed the wet-bulb depression. The temperature of the

wet bulb is affected in a measure by radiation from surrounding objects. It is, therefore, very susceptible to air currents which serve to increase the evaporation and therefore decrease the percentage of error due to radiation. On this account, the earlier and more convenient form of hygrometer using a stationary wet bulb is very unreliable, considerable correction being necessary for radiation. The sling psychrometer advocated by the United States Weather Bureau overcomes this error to a great extent by increasing the ventilation and consequent rate of evaporation to such a degree that the heat received by radiation becomes a small percentage of the total heat transformation.

The tables of the United States Weather Bureau based upon an empirical formula deduced by Prof. Wm. Ferrel from simultaneous determinations with the sling psychrometer and the dew-point instrument are more reliable, and are now generally used. The limitations of this formula are admitted, since it is held to be correct only over the range of observation from which it was deduced, including simply temperatures below 120° F.

Professor Ferrel's formula, as given in the tables of the United States Weather Bureau, is:

$$e = e' - (0.000367\ P)\ (t - t')\left(1 + \frac{t' - 32}{1571}\right)$$

where

e = partial pressure of the moisture in the air, which also = vapor pressure corresponding to the dew point,

e′ = the vapor pressure corresponding to saturation at wet-bulb temperature t′,

P = the barometric pressure,

t = dry-bulb temperature in deg. F.

t′ = wet-bulb temperature in deg. F.

The temperature of the dew point is found by selecting the temperature corresponding to the pressure e, from the temperature-pressure diagram or table. The per cent. of relative humidity is $R = \frac{e}{e_t}$, where e_t is the vapor pressure corresponding to the dry-bulb temperature t, as previously demonstrated. The absolute humidity expressed in grains of moisture per cubic foot is then determined by multiplying the grains of moisture per cubic foot corresponding to saturation at dry-bulb temperature by the per cent. of relative humidity thus determined.

The writer would substitute for such an empirical formula a rational one, having a thermodynamic basis—that is, a formula depending upon the transformation of sensible heat into latent heat in the adiabatic saturation of dry air.

The author first observed that the wet-bulb temperature given in the psychrometric tables of the United States Weather Bureau agreed substantially with the computed temperature at which air of a known temperature and moisture content would become saturated adiabatically—i. e., without the addition or subtraction of heat. These calculations were made by the writer in 1903, in determining the moisture-absorbing capacity of air in connection with the fan systems of drying. Subsequently, this relationship was still further investigated and thoroughly established in connection with the system of air conditioning introduced by the writer.

Tests upon progressive fan-system dry kilns in 1904 disclosed the fact that the wet-bulb temperature was substantially the same in all parts of the kiln regardless of the drop in temperature due to moisture absorption, a phenomenon which logically results from the identity of the wet-bulb temperature and the temperature of adiabatic saturation.

PSYCHROMETRIC PRINCIPLES

The following principles underlie the entire theory of the evaporative method of moisture determination, as well as of air conditioning:

(*A*) When dry air is saturated adiabatically the temperature is reduced as the absolute humidity is increased, and the decrease of sensible heat is exactly equal to the simultaneous increase in latent heat due to evaporation.

(*B*) As the moisture content of air is increased adiabatically the temperature is reduced simultaneously until the vapor pressure corresponds to the temperature, when no further heat metamorphosis is possible. This ultimate temperature may be termed the temperature of adiabatic saturation.

(*C*) When an insulated body of water is permitted to evaporate freely in the air, it assumes the temperature of adiabatic saturation of that air and is unaffected by convection—i. e., the true wet-bulb temperature of air is identical with its temperature of adiabatic saturation.

From these three fundamental principles there may be deduced a fourth:

(*D*) The true wet-bulb temperature of the air depends entirely on the total of the sensible and the latent heat in the air, and is independent of their relative proportions. In other words, the wet-bulb temperature of the air is constant, providing the total heat of the air is constant.

APPLICATION OF THE EVAPORATION CALORIMETER TO THE DETERMINATION OF THE SPECIFIC HEAT OF AIR

In consequence of the psychrometric principles A, B and C, the moisture content of air from accurate psychrometric readings may be easily computed, provided the required temperature is known, as well as the density relations in a mixture of pure air and saturated water vapor, and also the exact latent heat of water vapor, and the specific heat of air and of water vapor at any temperature.

Recent research into the properties of water vapor has fully established its properties to a great degree of exactness, with the possible exception of the specific heat, which is of minor importance in psychrometric calculations. The author, however, was surprised to find upon investigation that the usual value assigned to the specific heat of air was unquestionably incorrect, since it had been definitely proved to be variable, and not a constant as assumed by Regnault. Moreover, recent investigators conducting their experiments with modern apparatus, supposedly with extreme accuracy, differed from each other by more than 3%, and from the generally accepted value of Regnault by more than 2%. Therefore, in order to use a rational formula in the construction of accurate psychrometric charts and tables, it becomes necessary to determine the specific heat of air to a much greater degree of accuracy than is known at present.

(At the time of this writing, the author stated, he was not prepared to give any definite data with regard to such determinations, but presented a method of employing the evaporation calorimeter which apparently affords great accuracy and upon which greater reliance can be placed than upon previous methods.)

DERIVATION OF A RATIONAL PSYCHROMETRIC FORMULA

In considering the interchanges of heat occurring in psychrometric phenomena, it is essential to consider primarily the relative weights of dry air and of water vapor, rather than the usual density-temperature relationship—that is, it is necessary to express moisture content as weight of water vapor per pound of pure air, rather than as weight of water vapor per cubic foot of space. Moreover, this relationship is much more adaptable to all of the usual calculations in air conditioning and in meteorology. The author, accordingly, has constructed all his formulæ and psychrometric charts upon this basis. In the deduction of the formulæ and in the construction of the accompanying charts, the following fundamental data were employed:

a Standard barometric pressure = 29.92 in. mercury = 14.6963 lb. per sq. in. = 2116.3 lb. per sq. ft.

b Absolute temperature = t + 459.62° F.

c B. T. U. $= \dfrac{\text{heat required to raise 1 lb. of water from 32° to 212°}}{180}$

d Mechanical equivalent of heat $= 777.52$ ft.-lb.

e Specific volume of air = weight of 1 cu. ft. of pure air at 32° F. and 29.92 in. barometric pressure $= 0.080728$ lb. per cu. ft. Therefore $\dfrac{pv}{T} = 53.35$.

f Instantaneous specific heat of air $C_{pa} = 0.24112 + 0.000009\ t°$ F.

g Vapor pressure, Holborn and Henning's modification of the Theisen formula $(t + 495.6) \log \dfrac{p}{14.70} = 5.409\ (t - 212) - 3.71 \times 10^{-10}$ $[(689-t)^4 - (477)^4]$, as calculated in tables of Marks and Davis (1909).

h Specific volume of steam as calculated in steam tables of Marks and Davis (1909).

i Latent heat of water vapor.
$r = 141.124\ (689 - t)\ 0.31249\ (t = \text{deg. F.})$.
$r = 109.16 - 0.56$ deg. F.
(approximately between 40° and 150° F.).

j Instantaneous specific heat of water vapor (approximately)
$C_{ps} = 0.4423 + 0.00018\ t°$ F.

k Specific weight of water vapor at saturation for any pressure and temperature.

$$S = \frac{\text{specific volume of air}}{\text{specific volume of steam}}$$

With respect to the reliability of these data, those on the latent heat of steam may be accepted as absolute within 0.1%, since the agreement of recent investigators seems to have established the present values beyond question. Strange to say, however, the specific heat of air, as already pointed out, has not been established with accuracy within 2%.

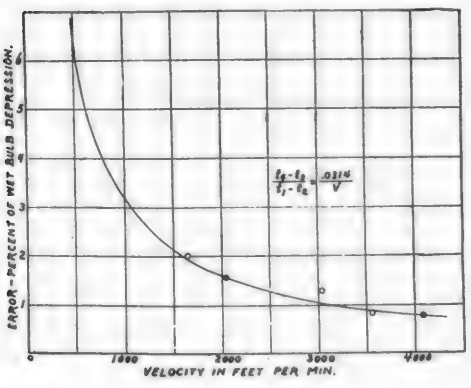

FIG. 5—RADIATION ERROR IN WET BULB OF SLING PSYCHROMETER

Regnault gives it as a constant, $Cp = 0.2375$, and this value has been generally accepted. However, Holborn and Henning, whose valuable determinations in steam are well known, have demonstrated it to be a variable. For nitrogen they give a value $C\ (o - t) = 0.2350 + 0.000019\ t$ (t in deg. Cent.), a straight-line relationship, although for superheated vapors they find equations of a higher degree. The plot of their values for C for nitrogen lacks considerable uniformity. So far as the points given are concerned, they do not seem to warrant assuming a straight-line relationship. Their points would seem to indicate rather a curve with considerably greater values at lower temperatures than given by their line. If their values were accepted at atmospheric temperatures we would have a specific heat for air considerably lower than that given by Regnault, while psychrometric evi-

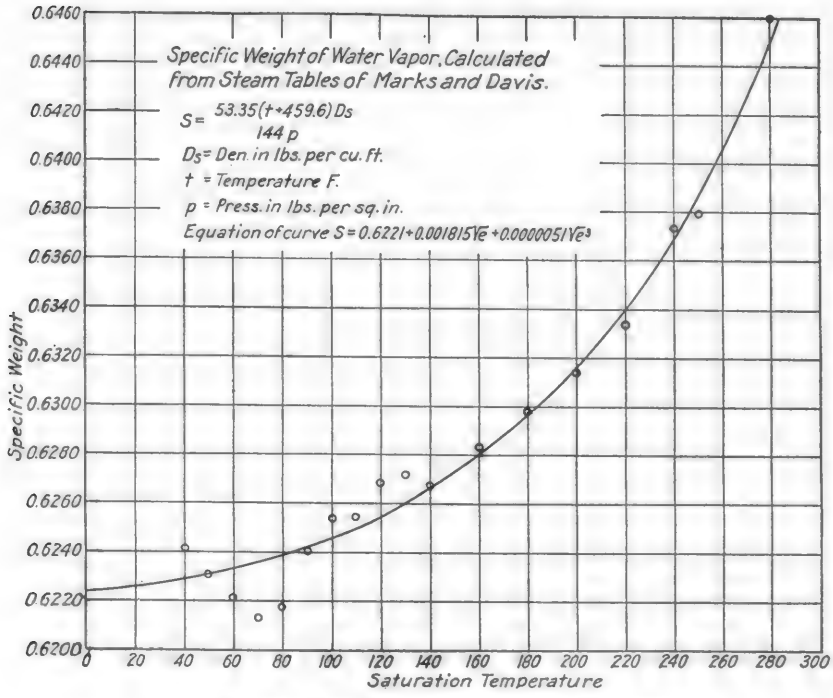

FIG. 6.—SPECIFIC WEIGHT OF WATER VAPOR

dence seems to indicate that it should be considerably higher at such temperatures. The most reliable of recent determinations would seem to be that of W. F. G. Swann. In his paper he points out a defect in the method of Regnault which would account for the latter's value being too low. The values given by Swann have therefore been adopted in this paper; although they appear still to require confirmation, since there would seem to be considerable opportunity for error in the method of air measurement used in his experiments.

The psychrometric charts, Figs. 1 and 2, are constructed accurately from the foregoing data. Fig. 2 exhibits all psychrometric relationships, between the temperatures of 20° and 380°, and saturation temperatures up to 143°. Fig. 1 gives the same values between temperatures 20° and 110° and saturation temperatures to 95°. These charts are here shown to a greatly reduced scale. In its original form, Fig. 1 permits the reading of both the wet- and dry-bulb temperatures to an accuracy of 0.1° and of the moisture weight per pound of air to 0.2 grains. All calculations have been made with accuracy to five significant figures by means of a Thatcher slide rule.

(In the complete paper the author here gives the formulæ from which his psychrometric charts were plotted.)

The need of an accurate rational psychrometric formula for vapor pressures using modern data is therefore apparent. The required values could be obtained indirectly from the formula already given, but computation is facilitated by another derivation giving directly the vapor pressure e.

(The author here shows the steps taken in deducing his rational psychrometric formula.)

$$e = e' - \frac{(P - e')\ (t - t')}{2800 - 1.3\ t'} \quad \ldots\ldots [3]$$

in which

e = vapor pressure of saturated water vapor.
e′ = vapor pressure at the dry-bulb temperature.
P = barometric pressure.
t = temperature of the dry bulb.
t′ = temperature of the wet bulb.

This formula will give values of e for all wet- and dry-bulb temperatures and all barometric pressures with an error of less than 0.5%.

This equation should be used where the true wet-bulb temperature is obtained as in the aspiration psychrometer. With the sling psychrometer a correction must be made for the error in depression due to radiation and stem correction. This is inversely proportional to the velocity. It is also, of course, greatly affected by the conditions of exposure—i. e., whether it is surrounded on all four sides by bodies at the temperature of the dry bulb, or only partly by bodies of that or a different temperature. The effect of radiation outside of an enclosure may be assumed to be approximately one-half of that within an enclosure.

A sling psychrometer 15 in. in length is ordinarily revolved between 150 and 225 R. P. M., giving a velocity between 1200 and 1800 ft. per min. This will give a radiation error of 2.6 to 1.75% within an enclosure, and 1.3 to 0.9% without an enclosure. Hence an average radiation error of 1.6% of the wet-bulb depression may be arbitrarily assumed. The wet-bulb depression given by the sling psychrometer may be corrected by this amount to give the true depression, which may be used in the foregoing psychrometric formula, or the formula itself may be modified to allow for this error.

If this formula is corrected for 1.6% radiation error

$$e = e' - \frac{(P-e')(t-t')}{2755 - 1.28\,t'} \quad \ldots\ldots [4]$$

for the sling psychrometer.

Using the true wet-bulb depression in formula [3], letting e_2 be the vapor pressure corresponding to saturation at the dry-bulb temperature t

$$R = \frac{e}{e_2} = \frac{e'}{e^2} = \frac{(P-e')(t-t')}{(2800 - 1.3t)\,e_2} \quad \ldots [5]$$

for the per cent. of relative humidity.

Let W be the grains of moisture per cubic foot at any vapor pressure e, and W_2 grains per cubic foot at e_2; then

$$W = (RW_2) = \frac{W_2}{e_2}\left[e' - \frac{(P-e')(t-t')}{2800 - 1.3\,t'}\right] \quad \ldots\ldots [6]$$

also

$$W = \left(\frac{460 + t'}{460 + t}\right) W_1 \qquad W_1 \ldots\ldots [7]$$

where W is the grains of moisture per cubic foot, corresponding to the dew point at vapor pressure e.

EFFECT OF CHANGE IN BAROMETRIC PRESSURE

Suppose that air in which the vapor pressure is e_0 is compressed from a barometric pressure P_0 to a barometric pressure P, then the partial pressure of both the air and the vapor are increased proportionally and $e = \frac{e_0 P}{P_0}$. The temperature corresponding to saturation at e is the temperature of the dew point at pressure P.

The per cent. of isothermal saturation becomes

$$R = \frac{e}{e_2} = \frac{e_0}{e_2}\frac{P}{P_0} = \frac{R_0 P}{P_0} \quad \ldots [8]$$

where e_2 is the saturated vapor pressure corresponding to the dry-bulb temperature t.

TOTAL HEAT CURVE

This curve shows the sensible heat in the air above a base temperature of 0° F., plus the latent heat contained in the water vapor at saturation, but not including the heat of the liquid. Since the wet-bulb temperature, or adiabatic lines contain all points having the same total heat (neglecting heat of liquid), the curve serves to determine the total heat in the air under any and all conditions represented by the chart. This is of great convenience in calculating refrigeration required to cool and de-humidify air. For example, suppose it is required to find the refrigeration necessary to cool 1 lb. of air containing 98 grains of

moisture and having a dry-bulb temperature of 95°, to a final temperature of 40° saturated. We find from the chart that the wet-bulb temperature is 75°. The total heat corresponding to a saturation temperature of 75° is 37.8 B. T. U., while the total heat at 40° is 15.3 B. T. U. The difference, 22.5 B. T. U., is the refrigeration required per pound of air.

Modern Design in Hospital Heating

(*Concluded from November Issue*)

"A type of heating system that is gaining much favor in large institutions as its advantages are becoming better known is the hot-water heating by forced circulation. By this is meant a system of hot-water heating in which a circulation is induced by means of a pump placed in the circuit of the mains, the water being heated by either exhaust or live steam, or by both. The advantages of this system are economy in steam consumption, ease of control, the maintenance of a constant temperature in the wards, and the ability to run the mains anywhere, regardless of the grades, thereby making possible the location of the power house at a desirable point, which is often not possible with a wholly steam system unless pumps or other devices are installed to return the water of condensation to the boilers or expensive pipe tunnels are built. Some of the disadvantages of this system are that it is necessary to have an independent steam system, as steam is required for other purposes in nearly all hospital buildings; that it requires a greater amount of radiation than a steam system and a consequent greater cost of installation; that it requires greater engineering ability or knowledge of design; and that it must be installed in a more careful and better manner than the usual type of steam systems. One of the great advantages and one that should not be overlooked, is the ability to control the temperature in the buildings by controlling the temperature of the water and the flow at the power house, besides the individual control of the radiators or coils. That this means much will be conceded when we consider the great variation in temperatures to which we who live in the East are subjected.

"In the New England States, for example, the temperature varies during the heating season from zero to 50°, and even more. As sufficient radiation must be installed to heat the rooms to 70° in zero weather, and as the average temperature for the heating season in New England is approximately 35° F., with a steam system of 100% more steam is used for heating than is actually required. If proper attention could be given and the radiation shut off when the temperature gets above 70°, this would not occur, but, unfortunately, this is not possible where there are a great many radiators or coils, and, besides, it is much easier to open a window and let the surplus heat escape.

"In some of the better class of hospital buildings, thermostatic valves are installed on the heat sources, which regulate the temperature of the building by regulation of the supply of steam to the radiation. Such devices are not only an expense to install, but are often found troublesome to maintain. Their installation the writer would recommend only to the better class of buildings and large wards and clinics where first cost is not to be considered. It may be claimed that it is possible to obtain a degree of regulation with steam by varying the pressure, but, even so, the best that can be obtained by such a method is by the use of high-pressure steam direct from the boilers, which is not good practice.

"A hot-water system is especially adapted to the heating of many widely separated buildings. Where ventilation or rapid air changes are required, fans supplying fresh air or exhausting

vitiated air are driven by electric motors. The hot water for all domestic purposes, also for the heating system, is heated at the central plant, and all apparatus centralized in the power house.

COMBINATION FORCED HOT WATER AND STEAM HEATING SYSTEM FOR A CANADIAN HOSPITAL

"A recent design for a large system of hospital heating and ventilating in the Dominion of Canada, where extreme temperatures had to be considered, may be referred to. After months of very careful study a combination system was adopted—namely, a forced hot-water system for all direct heating and a steam system for all tempering coils. Practically every room in the group of a dozen or more buildings is to be warmed by direct radiation. Tempered air will be introduced to all large wards and operating rooms and such other rooms as require rapid air changes. The ventilation will be entirely independent of the heating system and will be largely by exhaust fans on the roofs controlled by electric motors.

"The writer thoroughly believes in natural ventilation as far as possible. There are but very few days during the heating season that the well-trained nurse will not have the windows partly open to admit the health-giving fresh air just as it is provided by the Creator. At such times, the direct hot-water heat will probably care for the temperature of the rooms and the tempered air will not be required. Therefore, the fans introducing this air can be shut down and the expense of operation saved.

"I have often found entire systems where the wards were wholly dependent upon the introduction of air by fans or under pressure, where, owing to the great expense of operation, the same are not used or only partly so, and, therefore, no air is admitted to the rooms if doors and windows are closed, except what enters by wall or window leakage. In designing the plenum chambers and ducts, in this instance, they are so arranged as to introduce constantly tempered air by gravity, should the fans be closed; also, the system of ventilation will be open upon the same general plan by the introduction of aspirating coils either in the flues themselves or at the point of assembly on the roof. In this way, while we shall be able constantly to care for our room temperatures by direct radiation, we shall also have a natural gravity ventilating system that will give us from two to three changes of air per hour, even though the exhaust fans be closed down. This is perhaps the first combination hot-water and steam system of this nature applied to hospital practice, and, no doubt, will be watched with a great deal of interest. For a largely scattered institution located in a cold section of the country, what is now being planned for this modern hospital will, it is thought, prove the simplest, most economical and satisfactory of all systems."

Greenhouse Heating Charts

By John A. Payne

Attention is called to a transposition of the charts on this subject appearing in the last (November) issue. Chart 2 on page 39 and Chart 5 on page 32 should be transposed. The error will be obvious to anyone making use of the charts, but is here called to the attention of our readers, so that in filing these charts they may be given their proper place.

The Desired Increase of Power Obtained by Cutting Down the Back Pressure

It seems hard to realize that even today many manufacturers are throwing away their exhaust steam instead of utilizing it for heating or manufacturing purposes. Further cases have often arisen where a manufacturer needed more power to meet an increase of factory production and immediately purchased a new engine whereas the old one might have been made to do the work if its back pressure had been cut down.

A steam heating concern recently inspected a manufacturing plant where an increase of power was desired, as the factory output had somewhat increased. The manufacturers had about decided to put in a new engine, but, after having carefully considered the report of the engineers, concluded to put in a Webster vacuum system. It was found that with the vacuum system the back pressure was reduced sufficiently to enable the engine to perform the increased work.

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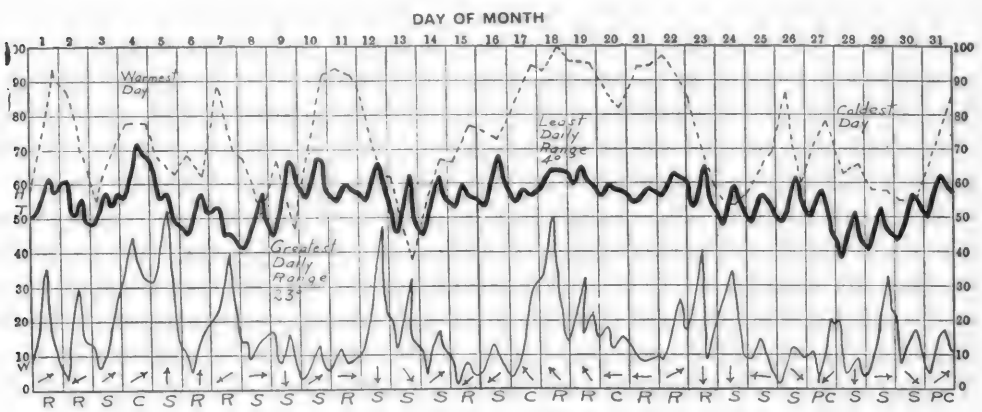
IT IS evident that the heating and medical professions have at last aroused themselves to a determination to discover the essence of good ventilation, or, at least, to learn the secret of what really constitutes "fresh" air. There is no denying the fact that the Government tests in this connection, coupled with recent theories of medical experts, have given a distinct jolt to those who felt that practically the last word had been said as to the character of the atmosphere. At the same time the new attitude towards ventilation has done little to clarify the situation as far as actual practice is concerned. It is easy to propose schemes that will serve very well as temporary expedients, but which are far too troublesome or unwieldy for continuous use. That is the present difficulty in the way of the adoption of most of the new theories regarding fresh air. In other words, the method whereby artificially warmed air is to be given precisely the same characteristics as outdoor air at the same temperature and humidity has yet to be worked out for adaptation to a mechanical heating and ventilating system.

The first steps in the important investigation about to be undertaken will be to identify this quality possessed by "fresh" air, which, it is claimed, is destroyed in passing through a modern heating system. The next step will be an effort to devise a mechanical arrangement of the ventilating apparatus best calculated to preserve the "freshness" of the air. While the details of the forthcoming investigations are not yet ready for publication, it may be said that influential members of both the medical and heating professions are coöperating enthusiastically on the project, and in one city have already secured facilities through the local officials for making the most ambitious ventilation tests ever undertaken in this country.

WHEN the matter of frequent temperature fluctuations was proposed as one of the solutions of the problem of good ventilation, the opinoin was expressed that it would be an easy matter to adjust the dampers in a hot blast or other indirect heating system so that currents of warm and, at least, mild air would be supplied during alternate intervals. The logic of this idea has recently been developed from the theory that human beings are most healthy when living an outdoor life. There they are subjected to continuous and often violent temperature fluctuations in the surrounding air, due partly to actual changes in the air temperature itself and partly to the cooling effects of the wind. Therefore, runs the argument, let us follow Nature and fluctuate our indoor temperatures.

The Weather for October, 1911

	New York	Boston	Pittsburg	Chicago	St. Louis
Highest temperature, degrees F.	72	73	77	79	88
Date of highest temperature	4	12	4	3	3
Lowest temperature, degrees F.	39	34	29	32	35
Date of lowest temperature	28	28	29	27	27
Greatest daily range, degrees F.	23	26	29	25	27
Date of greatest daily range	9	9	6	6	6
Least daily range, degrees F.	4	3	6	4	5
Date of least daily range	18	19	2	8	20
Mean temp. for month, degrees F	56	53	54	53	57
Normal mean temp. for month, deg. F.	56	52	54.9	53.2	58
Total rainfall, inches	5.38	2.27	4.94	3.79	2.63
Total snowfall, inches	0	0	0	0	0
Normal precipitation, this month, inches	3.71	3.86	2.36	2.55	2.41
Total wind movement, miles	11022	7023	6943	9507	7021
Average hourly wind velocity, miles	14.8	9.4	9.3	12.8	9.4
Prevailing direction of wind	S.W.	N.W.	N.W.	West	N.E.
Number of clear days	8	11	9	7	9
Number of partly cloudy days	8	6	8	9	6
Number of cloudy days	15	14	14	15	16
Number of days on which rain fell	20	11	14	17	10
Number of days on which snow fell	0	0	0	0	0
Snow on ground at end of month, in.	0	0	0	0	0


DAY OF MONTH
Warmest Day
Least Daily Range 4°
Coldest Day
Greatest Daily Range 33°
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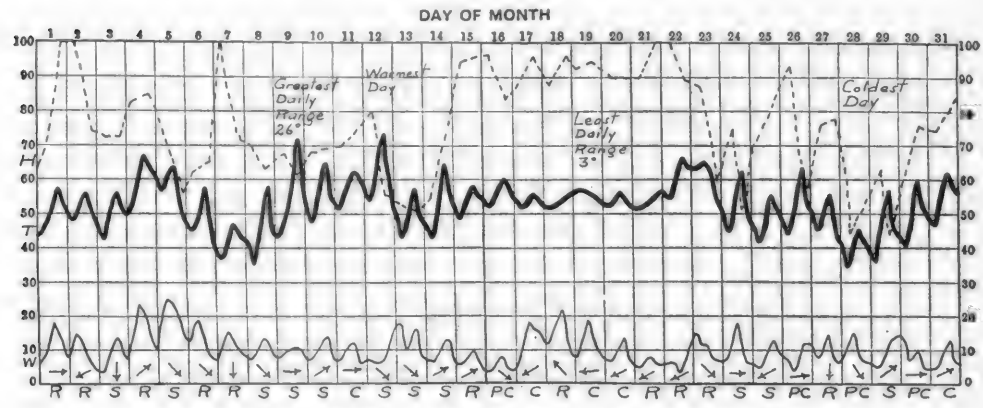
RECORD OF THE WEATHER IN NEW YORK FOR OCTOBER, 1911


DAY OF MONTH
Greatest Daily Range 26°
Warmest Day
Least Daily Range 3°
Coldest Day
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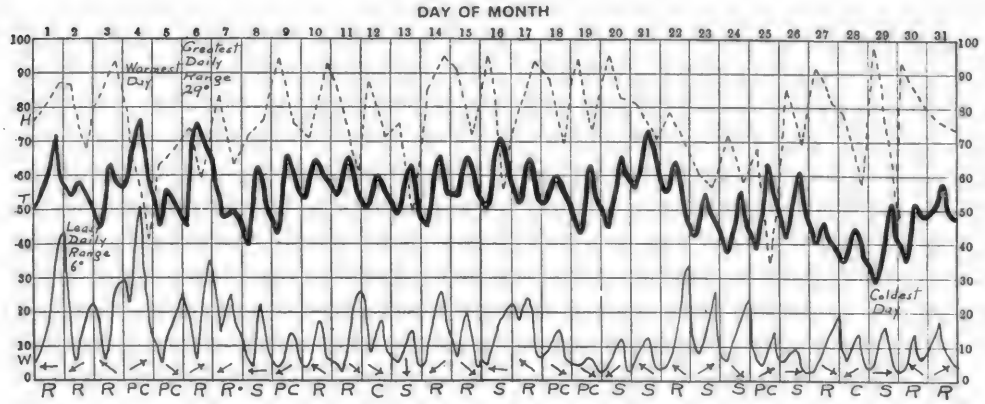
RECORD OF THE WEATHER IN BOSTON FOR OCTOBER, 1911


DAY OF MONTH
Greatest Daily Range 29°
Warmest Day
Least Daily Range 6°
Coldest Day
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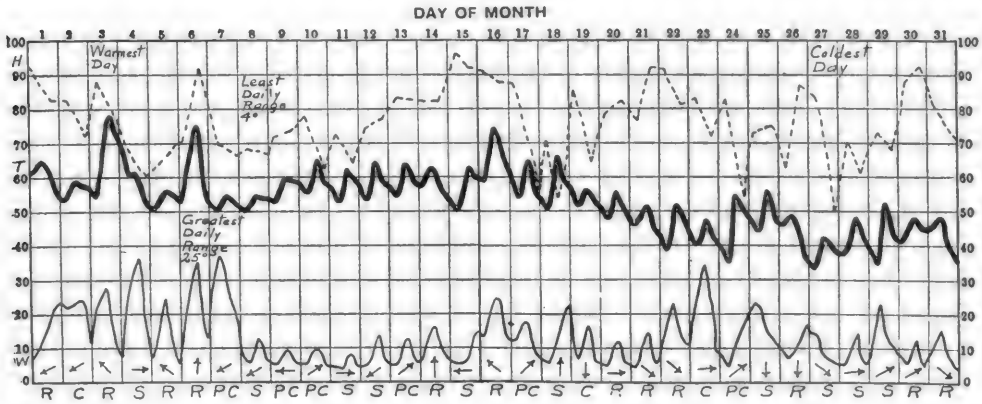
RECORD OF THE WEATHER IN PITTSBURG FOR OCTOBER, 1911


DAY OF MONTH
Warmest Day
Least Daily Range 4°
Coldest Day
Greatest Daily Range 25°
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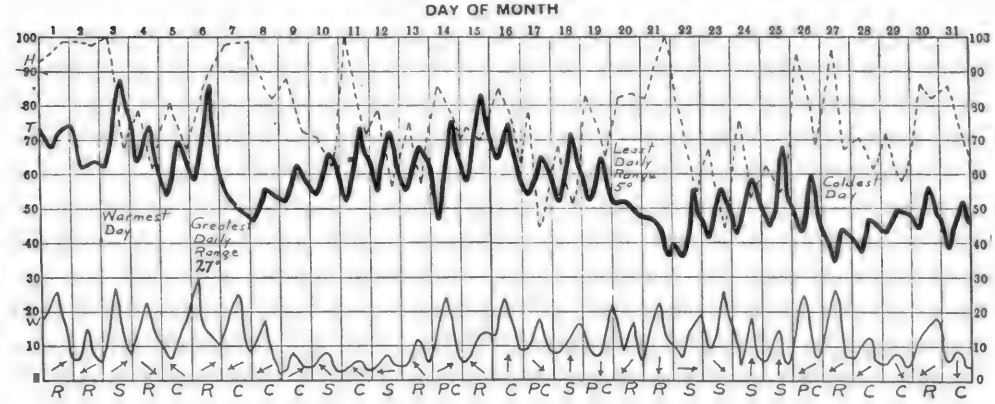
RECORD OF THE WEATHER IN CHICAGO FOR OCTOBER, 1911


DAY OF MONTH
Warmest Day
Greatest Daily Range 27°
Least Daily Range 5°
Coldest Day
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RECORD OF THE WEATHER IN ST. LOUIS FOR OCTOBER, 1911

Plotted from records especially compiled for THE HEATING AND VENTILATING MAGAZINE by the United States Weather Bureau.

Heavy lines indicate temperature in degrees F.

Light lines indicate wind in miles per hour.

Broken lines indicate relative humidity in percentage from readings taken at 8 A.M. and 8 P.M.

S—clear, P C—partly cloudy, C—cloudy, R—rain, Sn—snow.

Arrows fly with prevailing direction of wind.

CORRESPONDENCE

Peculiar Conditions in Steam Heating Plant

Editor HEATING AND VENTILATING MAGAZINE:

I give below a description of a peculiar condition existing in a direct steam heating system supplied from cast-iron sectional boilers of standard make and fed by means of an overhead steam main on a two-pipe system, supply mains being dripped at the present into a low return line, into which return risers are connected. Two boilers are used with the above system, each rated at about 6,000 sq. ft., while the system contains about 10,000 sq. ft. of direct radiation.

Trouble was first noted with the heating system when the same was placed in service at the beginning of the season, when the outside temperature was probably from 55° to 65° F. One boiler only was started up, and as soon as steam pressure in the same raised from 1½ to 2 lbs., the water was pushed entirely out of the gauge glass, apparently backing up in the return mains. This condition existed as long as the boiler was kept in service, i. e., for several days—whenever the steam pressure rose above 1½ lbs.

During this time a number of tests were made on the boiler and no difficulty was experienced in keeping the pressure even higher.

Thinking, perhaps, there was some defect with the boiler in use, the second boiler was cut in and the first boiler cut out, and the same conditions noted, i. e., steam pressure could be kept up with the greatest ease, and the water apparently left the boiler at least lower than the lowest gauge cock. During this time, also, practically none of the radiators on the first floor or basement could be heated, although the radiation on the upper three floors was hot. The plant was then run with both of the boilers in service and the entire system heated throughout, the boiler water line remaining practically stationary.

While the two boilers were in service the temperature dropped very suddenly to about 18° to 20° F. and no difficulty was experienced in either heating the building or maintaining the steady water line during the cold period. After the cold period had passed off and the temperature had arisen to about 45° to 50°, one boiler was cut out and the conditions noted at the time of operation with boiler were repeated.

I am at quite a loss to understand why, with only one boiler in use and very moderate outside temperature, the system does not fill with steam and why the pressure on the boiler does not fall if the steam condenses in the system, which would seem to be the case if the boilers were very much too small for the job. As far as can be learned, all the piping throughout is of adequate size, and a number of gauge readings taken on the radiators throughout the building would indicate very little loss of pressure.

The above plant was designed with the idea that one boiler would heat the same in mild weather, but up to the present time this has not been accomplished. I would be very glad to know whether or not you have had similar cases called to your attention and what the explanation would be, as at the present time I can see no reason why one boiler should not do the work.

J. L. EISER.

Baltimore, Md., November, 1911.

The conditions surrounding this job are extremely puzzling, if the real cause is not known. A vigorous draft and an intense fire account for the ability to show pressure on the boiler when one only is being used. Notwithstanding the show of pressure, one boiler is not able to carry the job under any weather conditions. Hence the water banks up in the system instead of returning to the boiler. To prove this, run one boiler with, at least, half of the radiation shut off. No doubt the job will then circulate properly.

Ten Formulas for Radiation

Editor HEATING AND VENTILATING MAGAZINE.

I have been considerably interested in studying the "Ten Formulas for Radiation" which you give in the October number of THE HEATING AND VENTILATING MAGAZINE, and I have made a careful comparison of all of them, together with the formula which I use in my own practice, and have prepared the following table of the results:

Formula	C factor	W factor	G factor	R
W.E.L.	0.0056	0.092	0.34	86.6
1	0.0056	0.084	0.32	82.1
3	0.0050	0.050	0.50	106.5
5	0.0102	0.070	0.28	87.3
8	0.0060	0.090	0.45	106.2
9	0.0052	0.071	0.50	109.9
10	0.00545	0.075	0.30	77.1

In the above table all of the factors have been reduced from the data given in the article to a similar basis and all formulas have been reduced to the exact form of formula No. 3, and the amounts of radiation as given in the last column of the table have been figured therefrom.

Formula No. 9 was reduced to a steam

basis by dividing by 1.4, the ratio between the temperature differences between the heating medium in the radiators and the temperature of the room in the case of

$$\frac{224-70}{180-70}$$

steam and water respectively

The last four terms in formula No. 10 were omitted as the corresponding quantities were not considered in any other case. The amounts of radiation given in the table have been calculated for a room of 3,000 cu. ft. contents, 130 sq. ft. of net wall area and 170 sq. ft. of glass. In each case the wall has been considered to be 12 in. or 13 in. thick and the glass to be single thickness.

Except in the case of formulas 3, 8 and 9 there is very little variation in the results for the room in question, although in the case of a corner room there would be a different ratio in the results.

Formula No. 5 gives a close average result in the case of the room selected for comparison, but in the case of a corner room where the cubic contents was small and the glass area excessive, a resulting amount of radiation would be obtained which would be too small for the proper heating of the room, due to the fact that the C factor is large and the G factor small.

The large amounts of radiation obtained from 3, 8 and 9 are due to the excessive allowance made for the glass area.

Formulas 2, 4, 6 and 7, as given in the article, are evidently incorrect as they all give ridiculous results as can be readily seen by the most casual inspection.*

I should be glad to receive the correct formulas for these cases and shall be interested in any further data you may receive on this interesting subject.

WILLIAM E. LELAND.

San Francisco, Cal., November, 1911.

*These four formulas, it is found, were incorrectly printed in the committee's report, and the committee has been unable as yet to procure the data in their original form. It is hoped that the author of the formulas in question will be able to furnish the needed corrections.—EDITOR.

Ventilating Appliances on Chicago's Elevated Cars

Replying to a complaint that the ventilators on some of the elevated cars in Chicago were opened "backwards" instead of facing the wind, President B. I. Budd states that the cars in question are equipped with floor intakes—i. e., there are about six openings, each 2 in. square, through the floor. Underneath the car there are scoops which force the air into the car on the floor line and the foul air is exhausted through the ventilators at the top of the car.

This plan of ventilation is in accordance with the city ordinance, and since the cars have been equipped with these ventilators it has been necessary to open the deck sash in a trailing position. If opened the other way there would be no chance for the foul air to escape except when the doors were opened at stations.

Air Inlets on Street Cars Admit Dust

A correspondent of the Chicago *Tribune* has noted that in dry weather some of the street cars are filled with an unusual quantity of flying dust. He states that several times he has seen passengers go to the platform to relieve their lungs of the dust that was choking them. On investigation he has found that the dust did not come in through the open windows or open doors which were, in fact, operating as air outlets. He then noticed a cloud of dust pouring out of a ventilator under the long seats at the front of the car. An opening had been made in the floor of the car through which air was supposed to be sucked in by the motion of the car, and after entering was intended to pass out through ventilators at the top of the car. Answering the complaint, an official of the Chicago Railways Company states:

"The municipal code requires that all street cars be ventilated and it is provided that the air must be taken into the car at a point below the height of the heads of seated passengers. The cars on Grand avenue are equipped with ventilating devices in compliance with the code. An investigation will be made of the car referred to, with the object of ascertaining whether there is any defect in the intake."

Changing the Air in Assembly Rooms

Writing in the Chicago *Tribune*, under a department entitled "How to Keep Well," Dr. W. A. Evans states: "Last week at the Illinois Federation of Women's Clubs, the proceedings were interrupted about once every hour by the opening of the windows. While they were open the ladies stood up. After a few minutes the windows were closed and the exercises resumed.

"Ten minutes in that fresh air," comments Dr. Evans, "and those quickened minds were worth as much as any thirty minutes where minds are dulled and the air is stale.

"At the Infant Welfare Congress the same plan was pursued. Prof. Henderson would call for little periods of recess; there would be a little stirring around, a little quickening of circulation, and then back to concentration of mind.

"The scheme is physiologically and psychologically sound. Now, why can it not be followed in offices?

"The ventilation almost everywhere is bad. Most of it was put in on the old plan of uniformity of temperature and

freedom from air movement. So much was planned. Not through planning but through oversight the air is usually harmfully dry. At this day we know there is no efficiency of mind or body unless the temperature varies and unless the air moves around enough to make its movement felt.

"Why should it not be good judgment for the chief clerk to have the office force —or the foreman have his factory force —stand up for five minutes out of each hour while the windows are thrown open and the room blown out. The fifty-five minutes remaining would be used for greater gain than the sixty minutes of the hours which flow along without a break.

"Where it is possible, it would be better to add to this plan an equipment of fans to keep the air moving during the remaining fifty-five minutes.

"This plan would not be ideal. For one thing, the air would be too dry. But it would make a lot of bad situations a good deal better."

House Heating Boilers in New York State Must be Insured or Inspected

A provision of Chapter 451 of the New York State laws relative to the inspection of steam boilers by the State fire marshal is attracting much attention, as it is found to include heating plants as well as power boilers. The provision in question reads:

"The State fire marshal shall also cause to be inspected all boilers in buildings and all other places where same are used for the generating of steam, except where a certificate has been filed certifying that such boilers have been inspected by a duly authorized insurance company. A fee of $5 shall be charged the owner or lessee of each boiler inspected by the inspector of the office of the State fire marshal."

There are in the State about 1,700 insurance companies whose certificate State Marshal Thomas J. Ahearn will accept, and the agents of these see to it that the fire marshal does not have to make an examination, if they can help it. To insure a boiler does not cost much in excess of the fee that the fire marshal would exact if he had to make an inspection, therefore the owners of boilers are convinced of the economy in taking out a policy of insurance in the first instance.

Under authority vested in him Fire Marshal Ahearn has made an order that all boilers generating 10 lbs. pressure and over of steam are subject to inspection. It is not generally appreciated, however, that this applies to heating plants as well as power plants, and that residences, as well as factories, come under the order.

The fact that the certificate of the insurance companies will be accepted by the State fire marshal in lieu of an examination by one of his deputies is admitted to be greatly to the advantage of the insurance companies.

Current Heating and Ventilating Literature

Under this heading is published each month an index of the important articles on the subject of heating and ventilation that have appeared in the columns of our contemporaries. Copies of any of the journals containing the articles mentioned may be obtained from THE HEATING AND VENTILATING MAGAZINE *on receipt of the stated price.*

CENTRAL STATIONS

Combination Heating and Generating Plant at Springfield, Ill. Illustrated description of a station furnishing electric energy for light and power, and low-pressure steam and hot-water systems for heating. 3000 w. Elec Wld—Sept 2, 1911. 20c.

FAN SYSTEM VS. DIRECT RADIATION

Fan System Versus Direct Radiation. Ira N. Evans. Power. Oct. 10, 1911. 6 figs. 7500 w. Shows the relative economy of each method when the physical conditions are favorable. 20c.

VACUUM HEATING

Vacuum Heating Systems. Charles L. Hubbard. Steam. Oct., 1911. 20 figs. 3700 w. 20c.

The First Authoritative Work on Central Station Heating

A notable book that will make its appearance the first of the year is entitled, "Notes on Central Station Heating," by Byron T. Gifford. Mr. Gifford is vice-president of the Central Station Engineering Co., of Chicago, and his extensive experience in the design and installation of district heating systems qualifies him to a marked degree to speak with authority on this subject. A portion of Mr. Gifford's matter appeared in serial form in THE HEATING AND VENTILATING MAGAZINE during the present year, but by far the larger part of his book is entirely new and is now for the first time published. The whole constitutes a review as well as an exhaustive data book on central station heating that ably fills a long-felt want in this important industry.

The work is being published by the Heating and Ventilating Magazine Co., 1123 Broadway, New York, and will be ready for delivery January 1, 1912. Orders are now being taken for delivery on that date, the price of the book being $4.00, postpaid.

Harrison's "Applied Heating and Ventilation"

A remarkable record for the sale of a high-grade work on heating and ventilation is reported by the New York Heating and Ventilation School, 1123 Broadway, New York, which states that, at the present rate of sales, the first edition of J. M. Harrison's "Applied Heating and Ventilation" will be entirely exhausted by the first of the year. This work, as is well-known, comprises the complete set of lesson sheets, with an additional number of charts used in the course of instruction in heating and ventilating engineering put out by this school. The demand for the book at the price at which it is sold, $10.00, testifies to the high character of the data it contains as well as to the demand on the part of the trade for practical information on the more important phases of steam, hot blast and forced hot-water heating.

America's Alleged Heating Trust

A startling article appearing recently in a Chicago paper entitled, "Nation to Fight Heating Trust," has aroused much comment, as the article went on to state that the Department of Justice in Washington has practically completed an investigation of the vacuum heating companies in the country with the result that it has evidence regarding four which is deemed worthy of careful consideration. A later dispatch states that Robert L. Gifford, of Chicago, president of the Illinois Engineering Company, went to Washington to investigate the basis for the story in which he is alleged to have furnished the information upon which the government would proceed. He was assured by officials of the Department of Justice, the dispatch continues, that no evidence had been obtained against the vacuum heating companies and that the statement to the contrary was without foundation.

The story went on to say that the four companies involved were Warren Webster & Co., Camden, N. J.; the Automatic Heating Company, New York; the Consolidated Engineering Co., Chicago, and the Illinois Engineering Company, Chicago, and continues:

"In the five years they are alleged to have been coöperating it is estimated by the government investigators they have collected $4,830,000 in license fees or royalties in less than thirty of the larger cities of the country.

"Because of these large royalties and their suits against smaller concerns, the government is interested in knowing whether they have been using their extraordinary profits in an effort to restrain trade.

FOUR HAVE COMMON AGENT?

"The federal agents report that this quartet has a common secretary or agent who receives a report of all sales and gives advice on charges to be made. His name is Robert McGantis, with an office on the fifth floor of the Royal Insurance building in Chicago.

"One of the officers of the four companies, said to be Robert L. Gifford, president of the Illinois Engineering Company, is reported to have given all of the details of the system employed. He is also said to have asserted that the companies have decided to quit their coöperative plan.

"Roughly speaking, vacuum heating systems provide for sucking the air out of steam coils and therefore pulling the steam through—instead of the old system of forcing the steam through the pipes. The principal part of the vacuum systems are patented valves. These four companies are said to issue a license, which they represent includes their expert engineering service, to use the patents. Then the system for a particular building is sold at a good profit, which consists principally of valves. No piping or radiators is included.

"After each member of the informal association makes a price for his system those figures are said to be sent to Mr. Gantis, who suggests the royalty fee which should be added. A certain percentage, varying from 25% to 33% of the royalties is left with Mr. McGantis, and from this fund costs of suits against smaller concerns are said to be paid. Nearly all of these suits relate to patents.

"The government is said to have the names of a few buildings on which the royalties paid were as high as $20,000, and in a number of structures the tax was between $5,000 and $10,000. One in the latter class is said to have been the new Northwestern Railroad station in Chicago.

"In this structure it is estimated that a reasonable selling price for the devices was possibly $1,000 or $1,500, but the license fee brought the aggregate to $7,000 or more.

ESTIMATES ON LICENSE COST

"The government estimate of the approximate license fees paid in the large cities in the last four or five years is as follows:

New York	$960,000
Philadelphia	275,000
Washington, D. C.	95,000
Baltimore	175,000
Pittsburgh	580,000
Boston	315,000
Cincinnati	125,000
Cleveland	145,000
Buffalo	85,000
Chicago	840,000
Detroit	70,000
Minneapolis and St. Paul	170,000
St. Louis	280,000
New Orleans	80,000
Denver	105,000

San Francisco	95,000
Los Angeles	120,000
Numerous smaller cities	315,000
Total	$4,830,000

USUAL RATE OF ROYALTIES

"These figures do not include the prices charged for the heating appliances installed. The rate of royalty usually followed is 10 cents a square foot of radiation on all jobs of less than 10,000 sq. ft., 8 cents on jobs between 10,000 and 20,000 sq. ft. and 7 cents on jobs involving more than 20,000 sq. ft.

"The inquiry was started, it is said, because of an experience of the federal government itself in the construction of the naval training station in Chicago. The government always declines to pay for royalties on anything, and did in this case. The Noel Construction Company, of Baltimore, had the general contract and a naval engineer named McKay was on the ground looking after the government's interest.

"The vacuum heating system purchased was the Van Auken, owned by the Consolidated Engineering Company, of Chicago, of which Byron E. Van Auken is secretary. McKay is said to have discovered that valves in one building cost $5, while the same valves in another building cost $10, and he wanted to know the reason for the wide difference in price.

"The leaders in the vacuum heating business are said to be James E. Hegg, president of the Automatic company; Warren Webster, of the company bearing his name, and Byron E. Van Auken. The Illinois Engineering Company is credited with disliking the methods of the others, but for self-protection is said to have been forced to enter into the coöperation."

American Society of Mechanical Engineers

A forward movement of the American Society of Mechanical Engineers in an effort to bring the engineering profession into a share of the prominence and leadership in public affairs now largely held by lawyers and financiers, was announced as the keynote of its annual meeting in New York, December 5-8, 1911. For this purpose more than forty committees were appointed, each one of which is to investigate some particular industry and thus permit the society to serve it for the betterment of industrial and social conditions therein.

The programme for the annual meeting included the following papers:

"Tests of Large Boilers at the Detroit Edison Company," by D. S. Jacobus.

"Strain Measurements of Some Steam Boilers Under Hydrostatic Pressures," by James E. Howard.

"Rational Psychrometric Formulæ: Their Relation to the Problems of Meteorology and of Air Conditioning," by W. H. Carrier.

"Some Experiences with the Pitot Tube on High and Low Air Velocities," by Frank H. Kneeland.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Dates Fixed for Annual Meeting

The dates for the annual meeting of The American Society of Heating and Ventilating Engineers have been definitely fixed for January 23, 24 and 25, 1912. In addition to the membership ballot sent out October 31, it is anticipated that another ballot will be issued in time to be canvassed before the annual meeting.

New York Chapter

An attendance of 20 members and guests was registered at the November meeting of the New York Chapter, which was held in the Engineering Societies building, November 14. The proceedings included a discussion of the "Aims and Purposes of the Chapter"; a short paper by Thomas Barwick, on "By Advice of Our Consulting Engineer," dealing with the relative efficiency of a city bureau and a private engineer with regard to work on city buildings; and a talk on "Ventilation of Moving Picture Shows," by Secretary Joseph Graham.

President W. M. Mackay appointed the following committee to act in connection with the parent body to arrange for the entertainment at the annual meeting: D. D. Kimball, M. F. Thomas, H. J. Barron, F. G. McCann and Thomas Barwick.

A proposal to make the meeting night the third Tuesday in the month, instead of the second, was laid over until the December meeting.

National District Heating Association

The executive committee of the National District Heating Association met in Detroit, Mich., November 8 and 9, to fix the time and place for the fourth annual convention of that association, and to arrange the program for that convention. The committee unanimously decided on Detroit, and fixed the dates, June 25, 26 and 27, 1912.

Papers upon the following subjects will be presented at this convention:

Depreciation in underground distribution systems.

Operation of turbines and reciprocating engines in connection with steam heating work.

Description of a combined steam heat-

ing, ice making and electric power system.

Radiation tests.

Heat losses in steam distributing systems.

Description of a large hot-water heating system.

Quality of steam supply as affected by use of superheat at station.

De-centralized heating plants.

Relative economics of one- and two-pipe heating systems in buildings.

Sources of trouble in customer's installations.

Thermo-dynamic economy of combined power and heating systems.

Different systems of underground construction.

One paper to be presented by the Cleveland Electric Illuminating Company, subject not yet announced.

The membership shows a substantial increase since the convention held in Pittsburg and the interest and enthusiasm in the work manifest.

Boiler Exhibit Showing Connection and Piping for Nine Different Heating Systems

The accompanying illustration shows a novel and interesting display of heating goods on exhibit in the New York showrooms of the Pierce, Butler & Pierce Mfg. Co., at 279 Fourth avenue. Nine different heating systems are here on view, all properly connected, giving a graphic illustration of the different methods and making it easy to compare them. The idea was suggested by James A. Harding, who is in charge of the salesroom, and, as carried out, have proven of much interest to the prospective owners as well as to engineers and contractors. The heating systems comprised in the exhibit are one-pipe steam, with direct and indirect radiators; down-feed, interchangeable steam and hot-water system; twopipe, upfeed, hot-water system; one or twopipe vapor or vacuum systems, with fractional radiator valves; and a hot-water heating system, with generator to accelerate the flow of the water.

The principal apparatus included in the display are the company's Modern boilers of varying capacities, Louraine radiators and Pierce wall radiators; also the company's Climax generator, for accelerating the flow in hot-water heating systems. The second boiler from the end, on the left, is connected to the system described as an overhead, down-feed, for either steam or hot water. This system is designed to be used with hot water in mild weather. For use with steam, the water is drawn off down to

EXHIBIT OF HEATING GOODS, SHOWING NINE DIFFERENT HEATING SYSTEMS

the water line in a steam boiler. The expansion tank, connecting with the riser at the right, is not shown. The main from this point is carried over and connected with the radiator at the top and bottom, permitting its use with either system. It will be noticed that with this arrangement the radiators each require two valves.

Pierce, Butler & Pierce Mfg. Co. is having the photograph of this display lithographed in large size and will shortly send out the hanger to the trade.

Bristol's Frictionless Ink Type Recording Instrument

To meet the demand for a frictionless ink type of recording instrument to parallel the smoked chart recorder as near as possible in fundamental simplicity and to accurately record fractions of milli volts and adapted for use as a recording electric pyrometer, the instrument illustrated herewith has been developed and placed upon the market by The Bristol Company, Waterbury, Conn.

These instruments have been tested out in practical service for two years past and are the result of several years of study and experience with an original* patented design of a frictionless ink recorder using a hinged electrical movement carrying a retaining receptacle for marking fluid which extends over the path of the recording tip and is provided

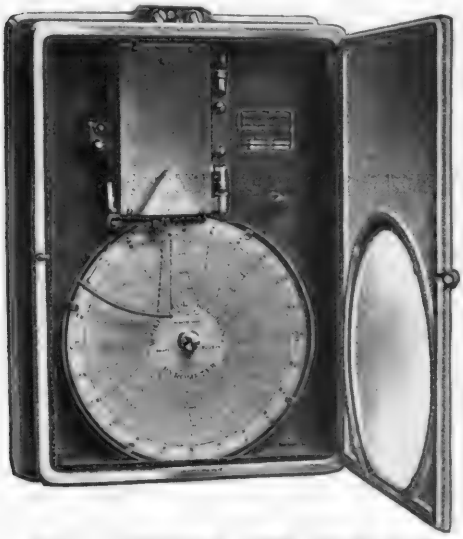

FIG. 1—INTERIOR VIEW OF BRISTOL RECORDER

with means for periodically making contact with the source of marking fluid and the chart.

Fig. 1 is an interior view showing the galvanometer movement case hinged to the back of the instrument and carrying the inking pad in front of the recording arm. Fig. 2 shows the sensitive electrical movement swung to one side for convenience in removing the record and inserting a fresh chart. A capillary gold tube open at both ends is carried at the end of the recording arm at right-angles to the surface of the chart. The inking pad is suspended from the case of the

FIG. 2—VIEW OF INTERIOR WITH ELECTRICAL MOVEMENT SWUNG TO ONE SIDE

electrical movement and is curved to correspond with the arc covered by the motion of the end of the recording arm.

When the movement is swung back into its operating position, as shown in Fig. 1, the recording arm can swing free, accommodating itself to the position corresponding to the delicate current which is to be measured. The clock which revolves the chart at the desired speed also automatically presses the inking pad toward the chart every ten seconds, bringing one end of the capillary tube into contact with the chart and the opposite end simultaneously into contact with the inking pad. A fine dot of ink is left on the chart and the capillary tube is replenished with ink from the pad. The recorder thus carries a constant supply of ink, and its balance, which is very important, is always maintained. The electrical movements used in these recorders are made especially for the purpose by the Weston Electrical Instrument Co.

Although the most important applications of these recording instruments have been for pyrometers, they have also been used for electrolytic research, recording voltmeters, and recording shunt ammeters.

*Patented by Wm. H. Bristol, April 13, 1909.

American Institute of Chemical Engineers

The programme for the forthcoming annual meeting of the American Institute of Chemical Engineers, which will be held at the New Willard Hotel, Washington, D. C., December 20-23, 1911, includes papers on the following topics:

"Combustion of Pulverized Coal," by L. S. Hughes.

Symposium on the United States Patent System, in which the principal speakers will be E. B. Moore, patent commissioner, U. S. Patent Office; Edward T. Fenwick, Walter D. Edmonds and R. N. Kenyon.

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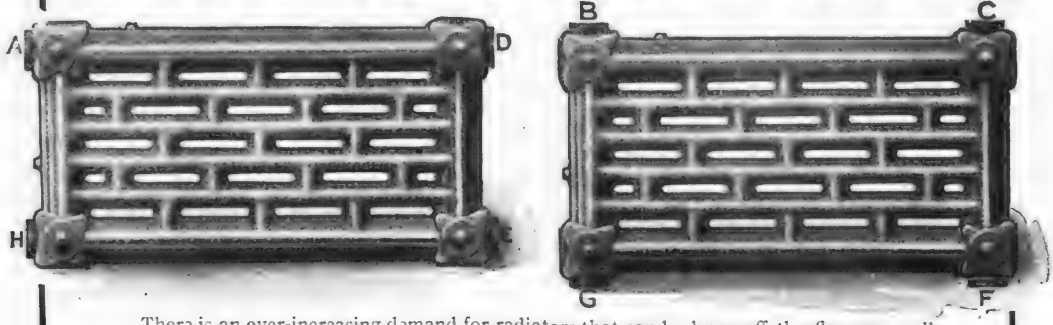
* Every other month.

OUT OF THE WAY RADIATORS



There is an ever-increasing demand for radiators that can be hung off the floor on wall or ceiling, placed in skylights, and still be practical, efficient heating surfaces.

No radiator made adapts itself better to space-saving conditions than the ATHENIAN WALL PATTERN of United States Radiators. Used in factory buildings where space is most valuable, in churches and schools, under windows to stop cold air currents, in assembly halls, stores, garages and all buildings where radiation should be off the floor.

The ATHENIAN WALL PATTERN is a most efficient wall radiator. Made in three sizes, connected with extra heavy right and left hand inside nipples. Has cross-bar circulation which increases its heating value, giving more efficiency than can be had in any other pattern of wall radiator.

Assembled in all shapes at the factory which saves labor cost on the job and they can easily be used in odd corners and out of the way places where regular radiation would be impossible.

It seems to us that you must be interested in this modern space-saving radiator, and we have prepared for your benefit a booklet that illustrates and describes in full the special advantages of this OUT OF THE WAY RADIATOR. It's free—Write for it to-day.

UNITED STATES RADIATOR CORPORATION

GENERAL OFFICES. DETROIT, MICH.

BRANCHES IN PRINCIPAL CITIES

Makers of more styles of radiation than any other individual manufacturer

TRADE AND MISCELLANEOUS NOTES

Coming Events

Second Tuesday in Each Month—Meeting of the New York Chapter, American Society of Heating and Ventilating Engineers, Engineering Societies Building, 29 West 39th street, New York.

December 13-14, 1911.—Annual meeting of the National Association of Brass Manufacturers in New York. Headquarters at the Hotel Astor, Broadway and 44th street.

December 20-22, 1911—Fourth annual meeting of the American Institute of Chemical Engineers in Washington, D. C. Headquarters at the New Willard Hotel.

January 23-25, 1912—Annual meeting of The American Society of Heating and Ventilating Engineers in New York. Headquarters at the Engineering Societies Building, 29 West 39th street.

Miscellaneous Notes

Baltimore, Md.—The new high-pressure pumping station on South street is so far advanced that the city has asked for bids for the installation of the heating and lighting plant. This idea was advanced some months ago by President John Hubert, of the Second Branch Council, who figures that by this arrangement the city can save more than $5000 per annum on its bills for heating and lighting. It will cost about $70,000 to install these plants, which include electric generators, steam engines and many electrical appliances. With the completion of this pumping station, the new highwater service will be put into use. It has been in the course of construction for several years and when finished the total cost will be about $800,000.

Freeport, Ill.—A movement is on foot to organize a company to put in a central heating plant for the business section of the city.

Buhl, Minn.—The council has instructed the city attorney to prepare an ordinance regulating the rates which are to be charged for heating service from the new municipal lighting system being put in at a cost of $20,000. Besides the

ENGINEERS AND STEAMFITTERS REQUIRE GOOD TOOLS

The GENUINE ARMSTRONG Stocks and Dies are

RELIABLE, ACCURATE, EASY WORKING

MANUFACTURED BY

THE ARMSTRONG MFG. CO., 321 Knowlton St., BRIDGEPORT, CONN.

THE McCREERY AIR SCRUBBER

Spray alone will not wash out **soot** and other **oily particles** from the air. These are what produce the **"smoke nuisance."**

Our Air Washers have therefore always been built with wet **cleaning surfaces** to catch the dirt and assist in humidifying and cooling the air.

The **flushing spray heads,** brought out by our Company, are now recognized as necessary to the uninterrupted operation of Air Washers and are specified by the leading Engineers.

The **Experimental Plant** originally installed by us in 1907, has been remodeled from time to time in order to obtain valuable knowledge of air conditioning.

We specialize in **Industrial Work,** as the high efficiency of our cleaning and humidifying device enables us to overcome difficult conditions.

Correspondence solicited.

McCREERY ENGINEERING COMPANY, DETROIT, MICH.

old and new schoolhouses the heat will be used in a considerable portion of the residence section.

Pittsburg, Pa.—At a meeting of the executive committee of the Master Boiler Makers' Association held at the Fort Pitt Hotel October 28, it was unanimously decided to hold the sixth annual convention of this association in Pittsburg, May 14-17, 1912, with headquarters at the Fort Pitt Hotel.

New Ulm, Minn.—According to recent reports, it is likely that the project for a central heating plant to supply the business section of the city, in connection with the municipal electric light and water plant, will be abandoned.

Milwaukee, Wis.—C. A. Crownhart, president of the Milwaukee Industrial Commission, reports that the commission is working in complete harmony with factory owners in working out the problems of better conditions in the factories. All improved systems of heating or ventilation suggested by the commission have been given a thorough test and proven good, and, as such, are adopted without protest by the factory owners.

Cottonwood Falls, Kan.—Being unable to heat the Chase county high-school buildings with a sufficient degree of comfort by using natural gas in their furnaces, the high-school trustees ordered the school closed until a different mode of heating could be put in. For several years the school has been using gas for heating purposes from the Elmdale fields, six miles west of this city.

Ypsilanti, Mich.—The proposition to bond the school district for $75,000 for a new school and a central heating plant was defeated at a special election.

Houghton, Mich.—A new Scharf smoke-consuming device has been attached to the furnace of the Dee central plant. The device has for its principle of operation the application of a jet of steam to the surface of the fire in the furnace when the doors are opened and fresh coal is being put on. The opening of the doors moves a series of levers which actuate a thrust pot, which in turn opens two draft doors in the fire doors of the furnace and at the same time turns on the steam jets. The steam, in combination with the air admitted through the draft doors, forms a gas which aids in the combustion of the smoke and the fine particles of coal arising from the fresh coal. After the furnace doors are closed the draft doors remain open and the steam jets continue for about three minutes, the time required for gravity to lower the plunger in the thrust pot and stop the operation.

Gloversville, N. Y.—The local city officials report a novel use of a steam roller to supply steam for the city hall when an important part of the mechanism of a new boiler being installed in the city hall was not shipped, rendering it useless for service.

Peoria, Ill.—A remedy for the ineffectiveness of the new heating plant of the Washington school has been discovered in the lengthening of the smoke stack. Fifteen feet have been added to it with the effect that the stack now draws sufficiently for the boilers, and the building can be properly heated.

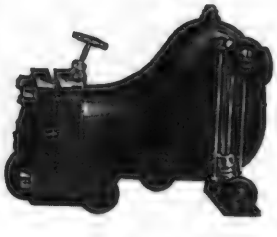
SPARE YOUR TOOLS

By using Dixon's Pipe-Joint Compound on joints. No damage to tools or fittings then when you want to open joints.

JOSEPH DIXON CRUCIBLE COMPANY, Jersey City, N. J.

McDaniel Improved Steam Trap

WILL DO THE WORK



When you need a Steam Trap buy one you know will work. With a McDANIEL we take all the chances. Don't pay until you are satisfied. We have been 25 years manufacturing Steam Traps and know there is no better trap made. May we send you one for trial?

Watson & McDaniel Co.

160 North 7th Street - PHILADELPHIA, PA.

Send for Catalogue

Boone, Ia.—The city council has voted to grant a franchise for a central hot-water heating station to the Boone Electric Company.

National Association of Brass Manufacturers will hold its annual meeting at the Hotel Astor, Wednesday and Thursday, December 13 and 14.

Newburyport, Mass.—Lester Dow, consulting engineer, of Salisbury, Mass., who was called in to ascertain the trouble with the heating plant of the new Currier school, found a large hole in the brick partition intended to separate the chimney flue from the hot-air ducts near the basement, preventing a proper draft and making it impossible to properly heat two or three of the rooms in the building.

Moberly, Mo.—A central heating plant is being discussed for Moberly.

Chicago, Ill.—At a dedicatory service held October 29, at the Thomas J. Waters School, Wilson and Campbell avenues, a memorial tablet to the memory of the late Thomas J. Waters, chief engineer of the board of education, who died February 25, 1909, was presented by Walter F. Caldwell, president of Local No. 143, International Union of Stationary Engineers, and was received on behalf of the board of education by the president, Dr. James B. McFatrich. The Illinois Chapter of the American Society of Heating and Ventilating Engineers was represented. Others present included a number of Mr. Waters' former associates in the Department of Education. Mr. Waters was a charter member of the American Society of Heating and Ventilating Enginers and served as a member of the council in 1895 and as vice-president in 1906.

Kalamazoo, Mich.—A proposed franchise for a central heating plant in Kalamazoo has been formally presented to the city council in favor of the Central Station Engineering Co., Chicago. The council already has a proposed franchise for the same purpose under consideration, introduced at the instance of the W. H. Schott Co., of Chicago. A committee of the city council has recently visited other cities in which central heating plants are in use, notably Kokomo, Indianapolis, Crawfordsville and Logansport, and returned favorably impressed with what it had seen. In Crawfordsville the party was shown through the plant by General Manager W. K. Martin. In describing the plant, Mr. Martin said: "We have found the hot-water system satisfactory, although, were we confronted with the problem of heating high buildings, I have no doubt steam would be used. We have six miles of mains running through the streets. The farthest point from the station reached by us is close to a mile away.

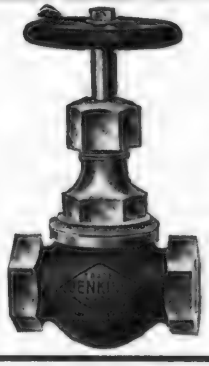
"We have established a flat rate largely because there has been no efficient hot-water meter devised. I would not say that the meter system is not the best. We start our plant the 15th of September, ordinarily, although this year we had no cause to get under way until the first part of October.

"Our plant was built by the Central Station Engineering Company and has never been changed except for an increase of boiler capacity, which we found necessary to take care of our customers.

"We secured our franchise from the city and in payment give free heat for the city buildings and city hospital. Our charge to the consumers is 17 cents per square foot of radiation.

"I will say, frankly, that I consider this charge too low and would increase it if I were to start over again. We have a capital of $200,000, of which $83,000 in stock has been sold and bonds in the sum of $83,000 have been issued. Our stockholders are all local men and are among the leading business men of the city.

"I believe our system is a little more expensive than coal, but I will say, frankly, that I do not believe you could go to the average consumer and get him



JENKINS BROS. VALVES

GLOBE, ANGLE, CHECK, SAFETY, BLOW OFF,

The most practical and economical. Each and every component part is designed to meet the requirements of exacting every day service. In metal and in workmanship care is taken to produce a valve that will give maximum amount of strength and durability.

We shall be glad to mail catalog on request.

JENKINS BROS.

NEW YORK BOSTON PHILADELPHIA CHICAGO

to change even though we increased our rate 25%.

"We dictate the amount of radiation for every home before it is installed, and will not take customers unless we are allowed to make the estimate. We do not, however, do any of the inside work ourselves.

"In all, I think we have about 200 customers."

Kiln-Dried Americans is the appellation given by a writer in the Milwaukee (Wis.) *Wisconsin* to the average house-dweller in America who provides no means for properly humidifying the air after it passes through the heating system. He quotes from a recent address by Dr. Paul W. Goldsbury, who states that "if the air outside should be carrying half a grain of water per cubic foot, which is perhaps a normal condition, and should be quickly heated and passed into the room, as is usually the case, it would be then in a condition when its appetite for moisture is increased eight times, and what it brought in from the street would be only one-eighth of what it ought to have to be relatively comfortable and healthful. It is true that the furnaces are usually provided with a water tank, but this is placed to suit convenience in filling it, and is in the colder part of the air chamber of the furnace, so that the air hurrying past has not either the time or the proper conditions to enable it to gather much as it passes, and is delivered into the rooms with little more moisture per cubic foot than it had out of doors. On the other hand, the indoor air, with its increased temperature, to be most comfortable and healthful, should carry about six grains per cubic foot.

"When these conditions are known one can begin to realize how much undermoistened the living rooms of houses are in winter. In official measurements of schoolrooms and hospitals, places for which provision is customarily made for proper air, the humidity has often been measured at below 3½ grains per cubic foot and occasionally below 1 grain."

Megaphones for use on street cars in announcing the street corners are being advocated in Chicago as a means of keeping the cars at the required temperature, through a less frequent opening of the doors.

Chicago, Ill.—A sub-committee of the council committee on city hall and public buildings has begun an investigation of the $107,000 heating and ventilating system in the city hall as a result of complaints of violent drafts and other alleged defects of the system.

United States Bureau of Mines, Washington, D. C., announces, through a bulletin on "The Physical and Chemical Properties of the Petroleum of the San Joaquin Valley, California," by Irving C. Allen and W. A. Jacobs, that, inasmuch as the art of burning heavy oils under boilers for steam raising has not been developed to its highest efficiency, the bureau will shortly undertake a thorough study of this problem.

A. Beaurienne, secretary of the Association des Ingénieurs de Chauffage and de Ventilation de France, will shortly visit the United States with the purpose of interesting the trade in a number of heating specialties designed by him. M. Beaurienne is the author of a number of papers on heating subjects, and recently contributed a paper on "Central Station Heating" to the National District Heating Association.

Manufacturers' Notes

American District Steam Co., North Tonawanda, N. Y., recently entertained a party of nearly 100 business men who had been invited to inspect the company's new plant and offices. The company recently completed its large new factory at North Tonawanda and moved its Lockport plant and office to the Lumber City. Many city officials of the Tonawandas were in the inspection party.

Canadian Sirocco Co., Ltd., Windsor, Ont., is the name of a Canadian factory

J-M Permanite Packing

Makes Flange Joints Permanently Tight

That is one thing a rubber packing cannot do, especially for high-pressure and superheated steam conditions.

Rubber will lose its elasticity, soon soften and go to pieces under high pressure.

J-M Permanite is made of the highest grade of pure Asbestos.

It will stand the highest temperature and the greatest pressure.

In addition to that especially prepared compounds are added, which make its resiliency and pliability almost equal to that of the best rubber sheet packings.

Has the all-important advantage of making a joint absolutely tight—permanently tight.

Never blows out—never burns out—never squeezes out.

Try J-M Permanite on the worst joints you can pick out.

Just see for yourself that J-M Permanite really is a packing that requires no following up.

Write nearest Branch for Sample and Booklet.

H. W. JOHNS-MANVILLE CO.

Baltimore	Kansas City	Omaha
Boston	Los Angeles	Philadelphia
Chicago	Milwaukee	Pittsburgh
Cleveland	Minneapolis	San Francisco
Dallas	New Orleans	Seattle
Detroit	New York	St. Louis

1178

which has been established for the manufacture of the products made by the American Blower Co., Detroit, Mich. The company has acquired a tract of land comprising 4½ acres, and will proceed at once with the erection of a plant which, when completed, it is stated, will be one of the most complete of its kind in the country. The company will hold the exclusive patent rights for the manufacture in Canada of the Sirocco fans and blowers.

Gurney Heater Mfg. Co.'s new plant, South Framingham, Mass., is practically completed as to the buildings, and the company anticipates having the factory in entire running order early next year.

Consolidated Engineering Co., Chicago, is building a factory and office building at Michigan terrace and 40th street, Chicago, Ill. It will be a two-story fireproof building, 85 x 135 ft., and will be completed about March 1, 1912.

American Radiator Co., Chicago, announces that the old A. A. Griffing Iron Works, Jersey City, N. J., was sold at public auction, November 22, to Mr. Kenney, of Plainfield, N. J. The property contains more than seven acres of ground, and is improved with a number of one and two-story brick and frame buildings, including the factory, storehouses, offices, etc., and also has about 4000 ft. of railroad track on the premises.

Crane Company, Chicago, is having plans drawn for a five-story steel and concrete building to be erected at Ninth and Webster streets, Oakland, Cal., at a cost of about $150,000.

New Incorporations

Hart Heating Co., Chicago, Ill., capital $30,000.

Commonwealth Heating and Contracting Co., Richmond, Va., capital $10,000. Incorporators: Jay W. Start, Chas. F. Campbell, Harry C. Glenn.

Shields Steam Specialty Co., Louisville, Ky., capital $10,000, to manufacture steam specialties. Incorporators: George W. Shields, A. J. Breedlove, T. Q. Munce.

Evans Fitting Co., Camden, N. J., capital $50,000, to manufacture steel fittings for hydraulic and steam piping. Incorporators: F. R. Hansell, J. A. MacPeak, I. C. Clow.

Northwestern Plumbing Co., Missoula, Mont., capital $10,000. Incorporators and directors: V. L. Bullis, R. H. Dunlap, O. B. S. Orr.

James F. Blackshaw Plumbing Co., Jersey City, N. J., capital $10,000. Incorporators: Jas. F. Blackshaw, Ann Blackshaw, Stephen J. Connelly.

Mizell Hardware Co., Heavener, Okla., capital $6,000.

Ouray Hardware Co., Ouray, Colo., capital $20,000.

Ventilating Systems Co., New York City, capital $100,000. Incorporators: E. M. Hall, J. C. Geisler, T. C. Hall.

Joseph H. Pryor Co., Brooklyn, N. Y., capital $100,000. Incorporators: Joseph H. Pryor, J. J. Harlin, A. J. Pearson.

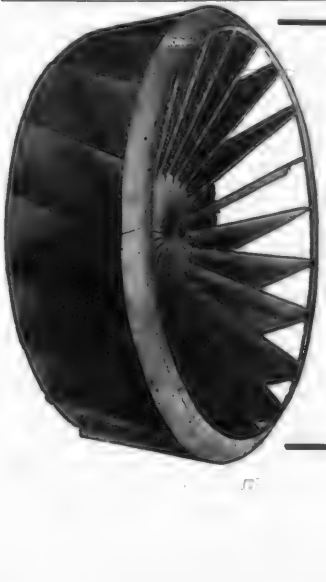
Sterling Brass Co., Cleveland, Ohio, capital $35,000. Incorporators: Alfred A. Benesch, Reuben Shapiro, Henry A. Rocker, E. M. Chalanpka, S. J. Kornhauser.

United States Steel Tank and Pipe Co., Chicago, Ill., capital $10,000. Incorporators: Henry N. Miller, S. M. Schall, A. C. Meyer.

New Firms and Business Changes

H. F. Luquire Plumbing and Heating Co., Macon, Ga., is the new name of the Alexander and Luquire Plumbing and Heating Co.

A. C. Eynon Plumbing Co., Canton, O., is erecting a large brick building at Walnut and Fourth streets, which it will occupy early in the year.



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A Cycloidal Fan or Blower

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W. H. Schott Company, central station engineers, Chicago, Ill., announces the removal of its general offices from the Steger building, to suite 1813-1816 The Harris Trust building, 111 West Monroe street, Chicago.

H. W. Johns-Manville Company, New York, announces the removal of its Birmingham, Ala., office from 1220 Empire building to 606 Chamber of Commerce building, the new quarters being better adapted for their growing requirements. W. H. Fleming, well known throughout this section, will continue as manager. A complete line of asbestos and magnesia products will be handled from this office.

McGinness Company, engineers and contractors, Pittsburg, Pa., announces that it has taken over the steam heating and ventilating contracts of the American Warming and Ventilating Company, together with the working force, engineers, tools and equipment of this department. Under the name of The McGinness Company the old force and management will complete the unfinished contracts, and continue in the steam heating and ventilating business.

C. A. Dunham Company, Marshalltown, Ia., announces that it has brought suit against Warren Webster & Co., Camden, N. J., in the United States Federal Courts alleging infringement of their patents.

Business Troubles

Ætna Heating and Ventilating Co., New York City, has filed schedules in bankruptcy showing liabilities $17,019 and assets unknown. Among the creditors are: J. L. Mott Iron Works, $4,417; Arthur H. Kohn, $3,600, and New Britain National Bank, $2,000.

Contracts Awarded

Mueller Heating Co., Milwaukee, Wis., heating new south wing of capitol and southeast and southwest pavilions, at Madison, Wis., for $38,472.

Thomas E. Gildea, Syracuse, N. Y., heating new Sumner School at that place, for $2,352.

Malone & O'Rourke, Utica, N. Y., heating Presbyterian gymnasium and parish house, at that place.

MacKinnon Boiler and Machine Co., Bay City, Mich., was the only bidder for heating city hall, at $2,000 per year; the bid was referred to a committee to ascertain what was charged for similar services in other cities.

Johnstown Supply Co., Johnstown, Pa., heating and plumbing new Eagles' home, in Johnstown.

"Triumph" Radiator Valves

"TRIUMPH" No. 42

ABSOLUTELY LEAKLESS
WITH NON-RISING STEM
QUICK OPENING AND CLOSING
SPECIAL HANDLE
FINE FINISH AND APPEARANCE
WORKMANSHIP AND EFFICIENCY UNEXCELLED

Also
CORNER, BACK OFFSET AND GATE

THE TRIUMPH VALVE COMPANY, Mansfield, Ohio

A. Holtman Heating Co., Kansas City, Mo., heating Missouri Pythian Home, Springfield, Ill., for $3,842.

Schweers Hardware Co., Green Bay, Wis., heating new county asylum, for $11,978.

Edmonds & Lovett, Kansas City, Mo., heating and ventilating addition to Yeager school for $2,578.

Walker & Chambers, New York City, heating new Mason Memorial Library building, Great Barrington, Mass.

Lynn, Mass.—The low bid for heating, ventilating and plumbing the new Eastern District grammar school was that of M. A. Dame Son Co., for $11,921. Other bids were: Huey Bros. & Co., Boston, Mass., $12,787; John F. Morgan & Son, $12,885; Nichols Drown & Co., $14,142; Sawyer & Hall, $14,505.

Mangrum & Otter, San Francisco, Cal., heating Gartland building, for $12,730.

M. D. Michael, Durant, Okla., heating new court house at Coalgate, Okla., for $17,500.

Rommel & Mueller Co., San Francisco, Cal., heating and plumbing new Alhambra school building, for $2,675.

Idaho Plumbing and Hardware Co., Boise, Idaho, heating and plumbing Government Reclamation Service building, for $2,999.

American Warming and Ventilating Co., Elmira, N. Y., heating and ventilating new Randolph (Vt.) schoolhouse, for $5,296.

M. J. Daly & Sons, Inc., Waterbury, Conn., heating, ventilating and plumbing two new factory buildings for Shoe Hardware Co.

New Haven, Conn.—Yale University's proposition to erect the new central heating plant, recently authorized, at Sachem street and Winchester avenue, is meeting with strong opposition on the part of the residents of that vicinity, who claim that the high chimney and the plant generally will result in a depreciation of property values.

McCusker Company, Portland, Ore., heating new wing of the Multnomah County Court House, for $70,727.

Robert Dalziell, Jr., Co., Oakland, Cal., heating, plumbing and galvanized iron work for the new Pantages Theater building; also heating and plumbing new four-story office building at Battery and Market streets, San Diego, Cal.

Cleghorn Company, Boston, Mass., heating and ventilating ten-story office building at Devonshire street and Spring Lane, Boston.

John H. Stevens, Manchester, N. H.,

The Lavigne Graduated Packless Valve
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The Lavigne Lock Shield Graduated Packless Valve

Is particularly well adapted for certain classes of work. Each size can be very accurately adjusted to a wide range of sizes of radiators, and the adjusting can be done by the heating contractor when installing the job instead of being done at the factory. It is also Fool Proof. Our Graduated Valves are also made with lever handle indicator. Send for our new circular fully describing our various styles of packless valves. Samples will be sent to interested parties.

Use Lavigne Packless Valves on Your Good Jobs

LAVIGNE MFG. CO., Detroit, Mich.

heating and plumbing convenience station in Merrimack Common, for $4,111.

Albert B. Franklin, Boston, Mass., heating and ventilating new Carnegie Library building, Brockton, Mass., for $4,400.

Freeland Supply Co., Hazelton, Pa., heating plant for Grand Opera House.

F. S. Spencer, Minneapolis, Minn., heating and ventilating Barnum (Minn.) high school.

M. F. Rourke & Co., Knoxville, Tenn., heating court house, for $5,378.

F. S. Schardein & Sons, Louisville, Ky., vacuum steam heating and plumbing Galt House, for $15,000.

Richard Sherwood, Billings, Mont., heating new building at the county farm.

John P. Rickards, Olney, Pa., heating Masonic Temple, Georgetown, Del.

Virginia Heating and Plumbing Co., Virginia, Minn., laying heating mains at Eveleth, Minn., for $19,600.

Business Chances

Washington, D. C.—Sealed proposals will be received at the office of the Supervising Architect, Treasury Department, for the following named work:

Until December 14, 1911, for the reconstruction of the U. S. Marine Hospital, Stapleton, Staten Island, N. Y., consisting of two three-story wings, reconstructing the entire interior of the old building and adding a fourth story to a portion thereof.

Until December 20, 1911, for the construction of the United States Postoffice, Westfield, Mass., consisting of a one-story and basement building, having a ground area of 4,350 sq. ft.

Until December 27, 1911, for the construction of the Postoffice, Court House and Custom House at Miami, Fla., consisting of a three-story and basement building, ground area of 7,200 sq. ft.

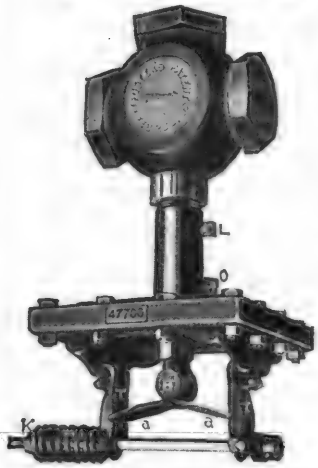
Until December 27, 1911, for the installation of a heating and ventilating apparatus, for the United States Postoffice and Custom House building at San Diego, Cal.

Until December 28, 1911, for the construction of the extension and remodeling of the United States Custom House, Boston, Mass.

Trade Literature

Buffalo Conoidal Blowers and Exhausters, so-called from the recurrence of conical shapes in their design, are featured in a new and comprehensive catalogue published by the manufacturers, the Buffalo Forge Co., Buffalo, N. Y. These are the company's new high-efficiency fans designed for large volumes and low pressures. The inlet is conical,

PRESSURE REGULATORS FOR STEAM HEATING



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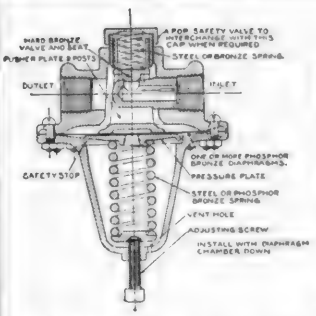
Foster Engineering Co., Newark, N. J.

the blast wheel forms the frustrum of a cone and the blades are curved over the tapering surface of a cone. The manufacturers state that the advantage of this form of construction is that without preventing the maximum amount of air to

SINGLE "CONOIDAL" FAN WHEEL.

be taken up in front, a uniform supply is secured at every point of the blade from front to back and the air is delivered at a pressure which comes close to uniformity over the entire width of the outlet. This form of construction prevents the air from being drawn in at right-angles to the back or drive side and then being deflected at an angle of nearly 90° towards the blades and outlet, thus losing power and velocity. Another advantage mentioned for the Conoidal fan is the practically constant efficiency curve which permits operation at from 20% to 30% above and below the rated capacity, giving a total range of from 40% to 60%, with only a slight decrease in efficiency. A section of the catalogue is devoted to data, including curves, on the performance of the Conoidal fans of various sizes, with different diverging nozzles. The various parts of the fan are illustrated in detail and there are also a number of views showing typical installations. Shop drawings are included, with detailed dimension tables for all sizes of fans, from 30 in. to 200 in., single and double width, and for various discharges. Size, 6 x 9 in. (standard). Pp. 48.

Ideal Heating Journal for November, 1911, the new periodical of the American Radiator Co., Chicago, contains an interesting article on "Thermal Tests of Heating Boilers," with an illustration, from a photograph, of the boiler-testing room at the company's Institute of Thermal Research, in Buffalo. This room is



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This valve is for pressure reduction and regulation in the following kinds of service:

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AIR———Pneumatic tools, oil burners, pneumatic water lifts, ballast tanks, torpedo discharge tubes, etc.

OIL———Fuel oil, pressure lubricating systems, etc.

GAS——Carbonic acid gas in soda fountains, breweries, water carbonating and bottling establishments, etc. Special valves for oxygen, acetylene, manufactured or natural gas.

Standard stock valves will be assembled for initial pressures up to 250 pounds and for such delivery pressure as specified from atmosphere to 150 pounds.

When writing please specify initial and delivery pressure and service.

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25 x 62 x 17 ft. high. There are 12 chimneys, each about 35 ft. high, with facilities for higher extensions when necessary, and varying from 8 to 24 in. in diameter. The photograph shows the tanks for measuring water evaporated in steam boilers, also a set of draft gauges for measuring frictional resistance in the fuel and flues. The article gives details of the company's method of testing boilers, and it is further stated that when a new design of boiler is being tested, glass plate windows are inserted in the boiler at convenient points. An electric light shows every movement of the water when the boiler is steaming. This device has been found to be an invaluable aid in making new designs. As the result of its tests, the company states that, in many cases, the catalogue ratings of its boilers have been shown to be but little more than half the maximum capacity of the boiler. Another article describes the United States Navy tests of Sylphon regitherms, used, in this instance, to control the temperature of the air in the powder magazines of battleships. Many other items serve to make the November number a notable issue.

J-M Packing Expert for November, 1911, published by the Cleveland branch of the H. W. Johns-Manville Co., contains an interesting item referring to the insulation installed in the Cleveland (O.) Federal building. The heavy boiler-iron smokestack, which runs up through the center of the building, was covered with 6 in. of J-M asbestos fire-felt sheets, with J-M roll fire-felt on the outside. Notwithstanding the difficulties of the work, it was successfully accomplished. All of the pipe covering was also furnished by the H. W. Johns-Manville Co.

Economical Steam Power Plants, a 24-page pamphlet published by the Green Fuel Economizer Co., Matteawan, N. Y., describes four of the largest modern steam power plants in the world, including the Hudson and Manhattan power station in Hoboken and the plant of the Laclede Power Co., St. Louis, Mo. The pamphlet also contains a fifth paper on economizer practice, discussing the theory of the lowest economical difference in temperature between the gases entering the chimney and the cold boiler feed water. It is shown that, whereas there is little economy in reducing the temperature of chimney-flue gases lower than 500° to 550° F. by means of boiler surface, the temperature of the same gases may be reduced to 200° F. or 250° F. quite profitably by means of economizer surface, because of the lower temperature of the contents of the economizer and the less costly nature of the economizer surface.

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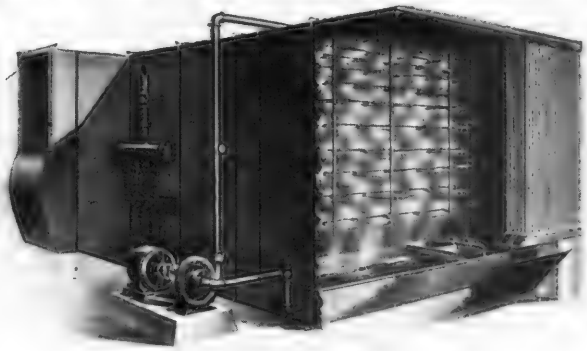

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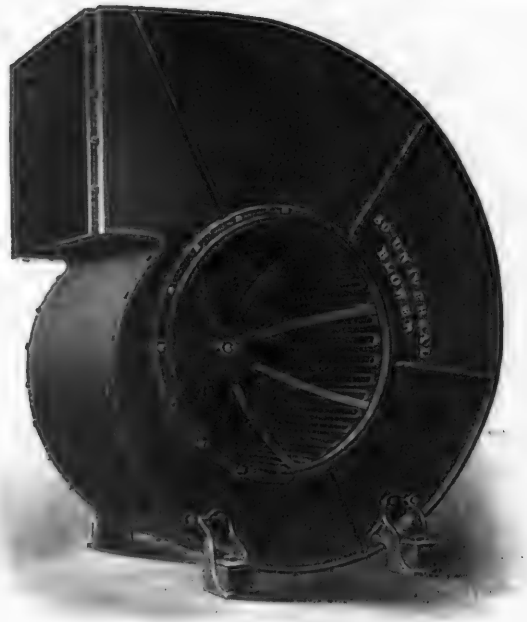

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Isometric Drawing Paper, on which a drawing may be scaled in the three main directions, the axes of which are 120° apart, one being vertical, the others being at 30° from the horizontal, has been placed on the market by the Norman W. Henley Publishing Co., 132 Nassau street, New York. It is furnished in pads of 40 sheets, 6 x 9 in., at 25 cents; or, 9 x 12 in., at 50 cents. The paper also comes in loose sheets, 12 x 18 in., at $1.00 for 40 sheets. By the use of this paper, any special knowledge of isometric projection is unnecessary, as it is easy to complete such drawings with but little calculation. All horizontal lines are laid along the 30° line in either direction. Thus a cube becomes a hexagon and circles ellipses. The advantage of this arrangement lies in the fact that one is enabled to make a scaled sketch, showing an article in its entirety, so that it is not necessary to study the details of an ordinary three-view drawing.

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Centrifugal Fans. By J. H. Kinealy. A theoretical and practical treatise on fans for moving air in large quantities at comparatively low pressures. 206 pages. 39 diagrams. Full limp leather pocketbook round corners, gilt edges. Price, $5.00.

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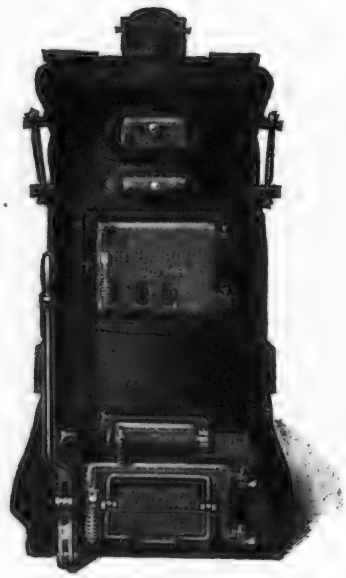

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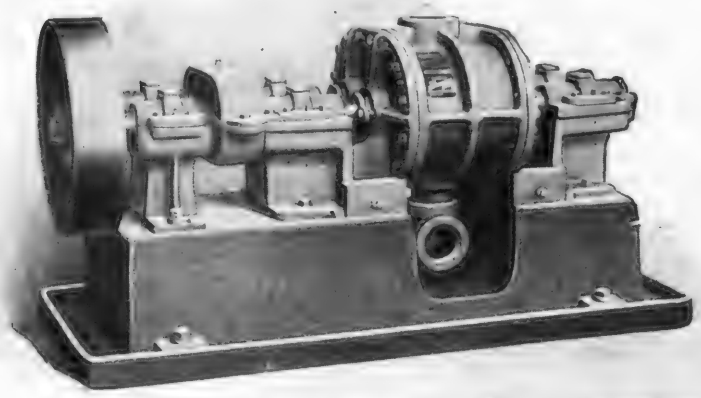

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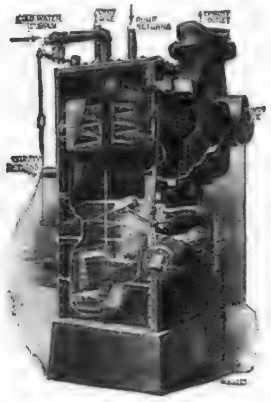
Figures relating to an electric power station of 6000 Kw. capacity recently prepared, showed that steam delivered to the engine cost 12.9 cents per 1000 lbs., when using coal costing $1.26 per ton. An analysis of other figures shows that in a boiler plant running 24 hours per day, 310 days per year, the cost of steam, with coal at $3 per ton and including other charges, is 19 cents per 1000 lbs., while in a plant of the same character, using coal at the same price, but running only 10 hours per day, 310 days per year, the cost for steam becomes slightly more than 21 cents per 1000 lbs. In smaller plants, especially those using hard coal, the cost may be considerably higher, perhaps as much as 50 cents per 1000 lbs.



Interior View of Cochrane Steam-Stack and Cut-Out Valve Heater and Receiver

Now, an automatic engine of moderate size, such as is usually installed for lighting and power in hotels, office buildings, factories, etc., will use from 30 to 35 lbs. of steam per H.P. hour. Taking the lower figure, a 100 H.P. engine will, in a day of ten hours, exhaust 30,000 lbs. of steam.

Now, for heating or drying purposes this exhaust steam is just as valuable as live steam, provided it is purified of oil by passing through a **COCHRANE OIL SEPARATOR.** A 100 H.P. engine will then exhaust each day about $5 worth of steam, which, if there are 200 days in a heating season, would amount to $1,000, which is a good many times more than a Cochrane Combined Heater and Separator would cost.

The unique superiority of the **COCHRANE STEAM-STACK AND CUT-OUT VALVE HEATER AND RECEIVER** in connection with exhaust steam heating systems lies in the fact that it combines within itself the functions of feed water heater, receiver, automatic make-up water regulator, and independent oil separator, that is, the oil separator attached to and forming a part of the heater is of sufficient capacity to purify of oil all the steam exhausted by the engine, including that used in the heating system. This saves buying an independent oil separator and the trap, valves, tees, elbows and other fittings required for its installation. Valves incorporated in the construction permit of cutting the body of the heater out of communication, while the separator continues to purify the steam passing to the heating system. These valves are connected to one lever, and there is no possibility of throwing pressure on the heater or of stalling the engines, as sometimes happens where an independent separator is installed in a by-pass.

THE COCHRANE STEAM-STACK AND CUT-OUT VALVE HEATER AND RECEIVER gives a better, more compact and safer arrangement than any combination of heater, independent separator, make-up water regulator, etc., but it costs considerably less. In other words, it saves from $50 to $500, as compared with the composite arrangement.

The owner of a large factory told us the other day that since he had put in an exhaust steam heating system, his bills for lighting, power and heating were not as large as the bills for heating alone when he used live steam for the purpose, and that his buildings were satisfactorily heated in the coldest weather. Perhaps you can make savings as great or even greater. Send us particulars about your plant and we shall be pleased to advise you.

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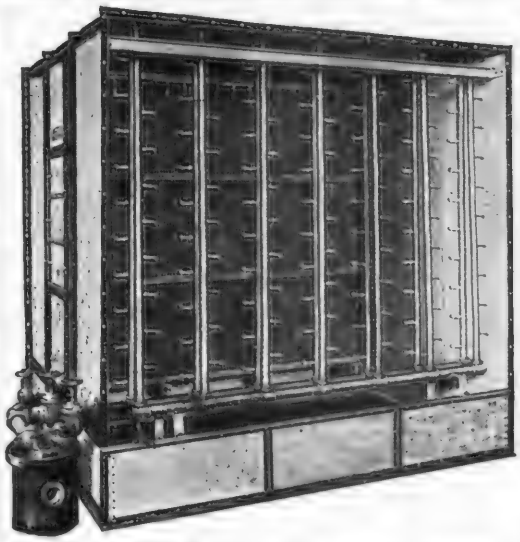

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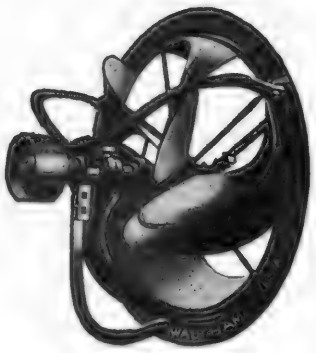

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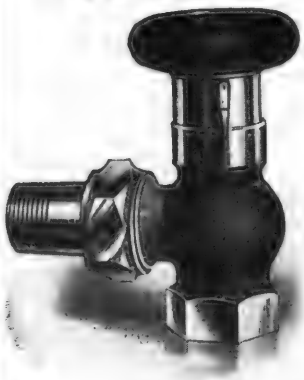

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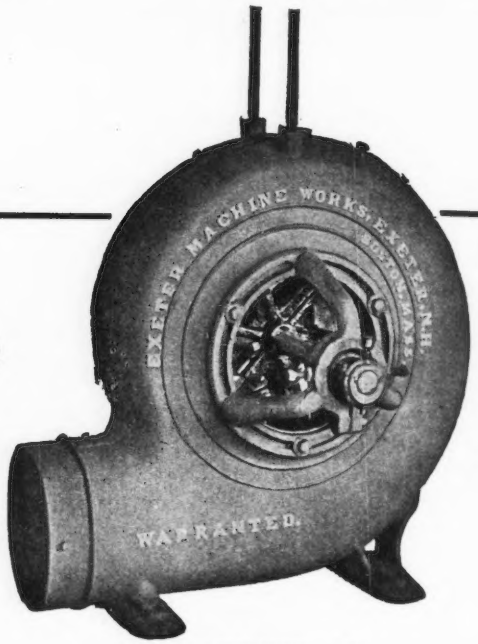

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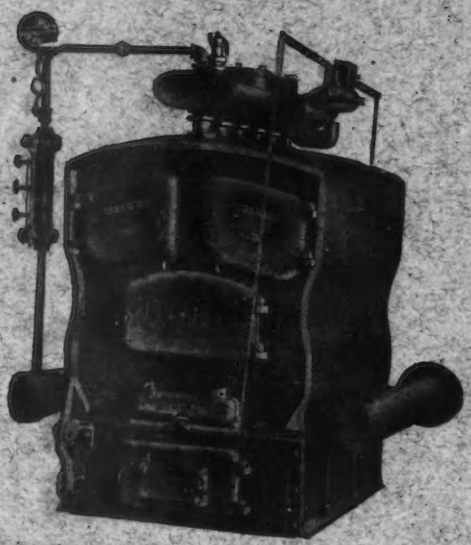

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